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MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

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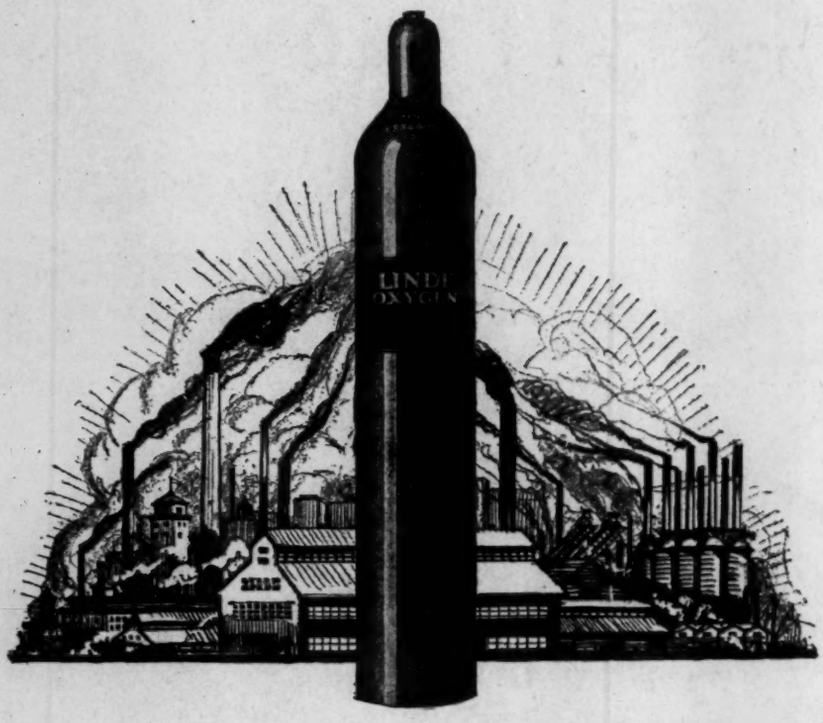
MARCH 1922

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



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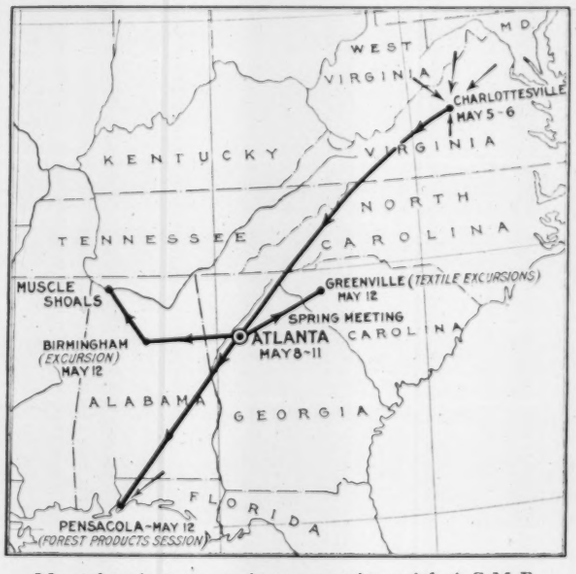

Map showing events in connection with A.S.M.E. Spring Meeting

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A Study of the Pumping-Engine Installations at Cleveland, Ohio, During the Past 65 Years—A New Record Performance at the Division Avenue Pumping Station

By L. A. QUAYLE,[1] CLEVELAND, OHIO, AND E. H. BROWN,[2] MILWAUKEE, WIS.

Cleveland, Ohio's, installations during the past sixty-five years make an interesting study of both the improvement which has been made in the economy of pumping engines, and the increase in energy available to the engine which has resulted from successive increases in steam pressure and temperature. These installations also cover the period of the introduction of stoker firing and the operating records show their effect on the overall economy.

In 1917 Cleveland's new Division Avenue Pumping Station was put into service. The results of recent tests of the units of this station are given in detail in the present paper, as well as results of the official tests of all of the nine other vertical triple-expansion pumping engines in service in the Cleveland Water Works.

The authors' investigation leads them to believe that the Division Avenue station contains at least one and possibly four engines whose duty record and thermal efficiency have never been equaled by any other steam-driven pumping engine, namely 211,000,000 ft-lb. of work per 1000 lb. of steam used and 24.3 per cent thermal efficiency. They consider that the development which has led to such high efficiency in water-works steam pumping engines that require in general a maximum of not over 1500 hp., has been largely the result of the practice, instituted by water-works engineers, of making economy tests on all installations.

THE crank-and-flywheel vertical triple-expansion pumping engine originated from the designs of high-duty pumping machinery made under the direction of the late Edwin Reynolds. The first engine of this type was installed in the Milwaukee Water Works in 1886, is still in constant service, and differs but little in appearance and general design from the most modern unit. The high mechanical and thermal efficiencies of Reynolds' design were early recognized, and many elaborate and accurate tests were made on different installations. The first which attracted general attention were made by R. C. Carpenter and published in the Transactions of the Society in 1893.[3] The Reynolds design has been adopted by water-works engineers as a standard for American practice, and has been extensively copied abroad.

The introduction and adoption for general water-works service of this slow-piston-speed type of unit with its resulting enormous weight per unit of power, at a time when the whole tendency of prime-mover development was toward high speed and moderate unit weight, as evidenced by the extensive use of the Holly Gaskill type of pumping engine, the Porter-Allen high-speed general-service engine, and also the introduction of the Parsons turbine for small-generator drive, would have been impossible were it not for the very high efficiency over wide variations of capacity and head, and the great reliability inherent in pumping units of this type.

So far as the authors know, there is no record of any triple-expansion pumping engine having been wrecked or broken beyond standard commercial repair, and there are records available of engines of this type having run continuously with only a few hours' shutdown for adjustment and minor repairs for a period of over ten years.

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From the standpoint of engine and boiler depreciation, the engine longest in service was Cornish No. 2, which was put in operation at Division Avenue in 1856, moved to Fairmount Station in 1885, and taken out of service in 1905, making a total of 49 years from the date of first operation until it was permanently shut down because of obsolescence. Worthington engine No. 3 was installed in 1884 and is still in service at Fairmount Station, a total of 37 years to date. The boilers longest in the Water Department service were the Cornish purchased for Division Avenue in 1872, moved to Fairmount Station in 1894, and finally dismantled in 1905, making a total of 33 years from the time of purchase until they were dismantled with the Cornish engines because of obsolescence.

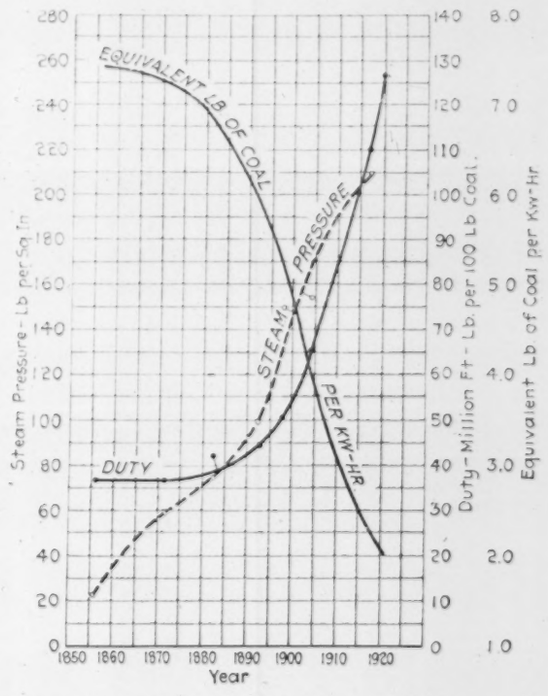
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FIG. 1 STEAM PRESSURE AND ECONOMY, CLEVELAND'S PUMPING STATIONS, 1856–1921, NO ECONOMIZERS

The effect of increased steam pressure, improvement in boiler and stoker efficiencies, and the changes in pumping-engine design have been summarized graphically in Fig. 1, which shows the steam pressure, together with the duty obtained from the different installations, plotted as a function of the time in years. It is interesting to observe that the increase in steam pressure from 22 lb. in 1856 to 80 lb. in 1883, did not result in higher duties owing to the fact that Cleveland purchased duplex pumps with the first increase in steam pressure. The purchase of this type of pump probably resulted from the low prices due to the adoption of the duplex direct-

[1] Chief Mech. Engr., Cleveland Water Dept. Mem.Am.Soc.M.E.
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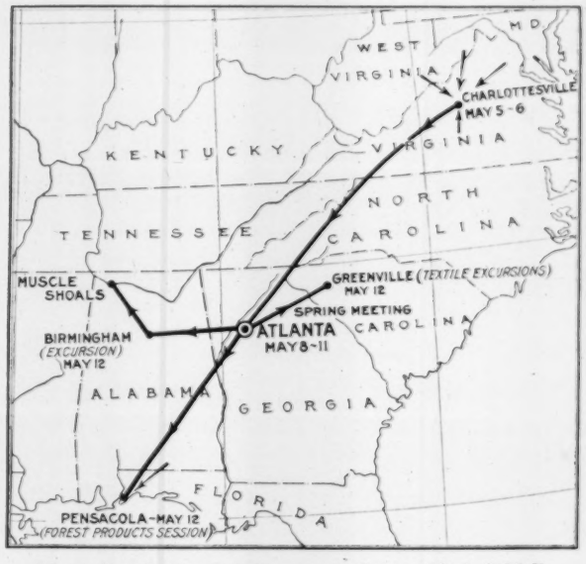

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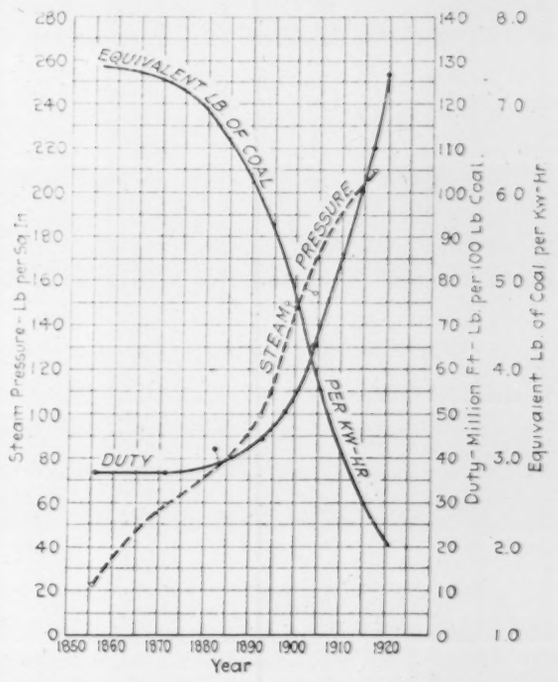
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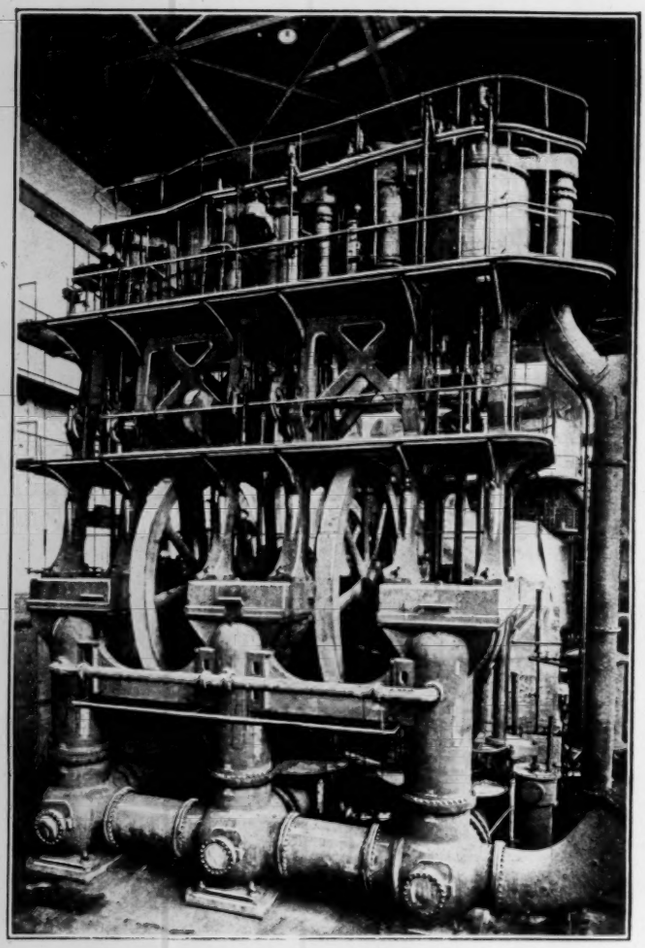

Fig. 2 Allis-Chalmers Engine No. 3 with Lagging Removed

acting Worthington design by a large number of pump builders following the expiration of the basic patents.

It is interesting to note in connection with boiler-room obsolescence that at the Division Avenue Station in 49 years of active service (1856 to 1905) there were 14 different boiler installations, making a total of 53 boilers of six different types. This station started out in 1856 with the same number of boilers (six) for a pumping-station capacity of 8,000,000 gal. per day as the new station is now provided with for a capacity of 150,000,000 gal. per day.

In 1904 Kirtland Pumping Station was put in service using 155 lb. gage boiler pressure and 120 deg. superheat, and with a greatly improved boiler plant which resulted in an increased station duty per 100 lb. of coal of approximately 47 per cent as compared with the best Division Avenue Pumping Station records, although the engine duties per 1000 lb. of steam were not greatly increased, as is shown by the official duty tests listed as Item No. 71 in columns Nos. 10, 11, 14, 15, and 16 of Table 2. Eight years of progress in pumping-engine design are reflected in the increase in duty of Holly engines Nos. 6 and 7 of about 9 per cent when tested under approximately the same pressure and superheat as Holly engines Nos. 2 and 3, a portion of the gain resulting from a better vacuum due to the use of water-works-type surface condensers instead of the jet type with which Holly engines Nos. 2 and 3 were equipped.

In 1917 Cleveland's new Division Avenue Pumping Station was put into service. As far as the authors have been able to determine, the average duty of this station with a performance equivalent to 127,000,000 ft-lb. of work per 100 lb. of coal fired is not exceeded by any other coal-fired pumping plant in which the normal low cost of coal does not warrant investment in economizers. This low coal consumption is due to the use of efficient boiler and stoker equipment operated under constant engineering supervision and the use of highly efficient triple-expansion engines working under 210 lb. steam pressure and 120 to 150 deg. superheat.

Our investigation also leads us to believe that this station contains at least one and possibly four engines whose duty record and thermal efficiency have never been equaled by any other steam-driven pumping engine. The best economy obtained on any one of these four engines—211,000,000 ft-lb. of work per 1000 lb. of steam used and 24.3 per cent thermal efficiency—is compared in Table 1 with a summary published in Kent[1] of the most notable high-duty pumping-engine records.

It is instructive to compare the thermal efficiency (including auxiliaries) of 24.3 per cent obtained on the 1400-hp. vertical triple-expansion pumping engine with 24.8 per cent, the maximum thermal efficiency (excluding auxiliaries) of the Interborough Rapid Transit 45,000-hp. cross-compound turbo-generator; with 24.1 per cent, the maximum thermal efficiency obtained by any one of four 40,000,000-gal.-per-day low-head 300-hp. Humphrey gas pumps at Chingsford, England; and also with the 24.1 per cent thermal efficiency obtained on a 1500-hp. natural-gas-engine generating unit of the American Locomotive Co. at Allegheny, Pa., as it shows that these four distinctly different types of units have all reached a point of development at about the same time at which they give practically the same thermal efficiency. This would seem to indicate that any large improvement in the future of any one type must call for a radical departure from the present trend of development.

The foregoing comparison of records made by different types of units emphasizes the relatively small horsepower of the pumping engine. The authors consider that the development which has led to such high efficiency in water-works steam pumping engines that require in general a maximum of not over 1500 hp., has been largely the result of the practice, instituted by water-works engineers, of making economy tests on all installations.

The rebuilding of Division Station which resulted in the economies referred to included the installation of three new Allis-Chalmers units, two of 25,000,000 gal. per day capacity against 250 ft. head and one of 20,000,000 gal. per day capacity against 380 ft. head.

TABLE 1 COMPARISON OF ECONOMY RECORDS AS GIVEN IN KENT'S HANDBOOK WITH DIVISION AVENUE STATION SPECIFICATIONS ADDED

Date of test	1899	1900	1900	1901	1906	1915	1918	1918
Locality	Wildwood, Pa.	St. Louis, Mo.	Boston, Chestnut Hill	Boston, Spot Pond	St. Louis, Bissell's Point	Cleveland, Division Ave.	Cleveland, Division Ave.	Cleveland, Division Ave.
Expansion	Quadruple	Triple	Triple	Triple	Triple	Triple	Triple	Triple
Figures based on	Test	Test	Test	Test	Test	Specifications	Test under specifications conditions	Test using receiver heater
Ft-lb. of work done per million B.t.u consumed	162.9	158.07	156.8	156.59	158.85	170	176.3	189.2
Corresponding thermal efficiency, per cent [1]	20.95	20.32	20.15	20.13	20.42	21.95	22.61	24.27
Equivalent B.t.u. per kw-hr.,[2] including all condenser and other auxiliaries	16280	16780	16930	16940	16700	15600	15070	14030

[1] The thermal efficiency in water-works practice is computed from an actual mean condensate temperature and not on the assumption that the condensate leaves the engine at the temperature of the exhaust steam, and also includes the power required for all the engine's auxiliaries.

[2] = 2,654,200 ÷ Ft-lb. of work done per million B.t.u. consumed.

[1] Mechanical Engineers' Pocket-Book, 9th Edition, p. 806.

The specifications for these units called for a duty for each of not less than 170,000,000 ft-lb. of work for each million heat units consumed when supplied with steam at 200 lb. gage pressure and 100 deg. fahr. superheat and with only exhaust steam used for feedwater heating.

The results of the tests of the new Division Avenue units are given in detail in the first four columns of Table 2. The other columns present the results of the official tests of all of the nine other vertical triple-expansion pumping engines in service in the Cleveland Water Works.

The economy of all the units covered in the test results in Table 2 is indicative of the efficiency of this type of engine when built in a wide range of sizes—the smallest being Holly engines Nos. 4 and 5 of 155 hp. and the largest, Allis No. 4 of 1400 hp.—and operated under greatly different steam conditions, and is also indicative of the excellence to which the design has been brought by the different builders.

The performance of Allis engines Nos. 2, 3, and 4, previously referred to can be taken as applying in general principle to the vertical triple-expansion type of pumping engine, and the following interesting developments which were brought out by an analysis of the test results bear on certain characteristics the authors believe are worthy of special consideration.

As the major loss in efficiency ratio is due to incomplete expansion in the low-pressure cylinder, it follows that the efficiency ratio should increase rapidly if this loss is reduced by increasing the exhaust pressure. This conclusion is confirmed by the results of a series of variable vacuum tests plotted in Fig. 3. These tests show that the efficiency ratio of the steam cylinders increased from 73 per cent at 0.725 lb. per sq. in. (28.52 in. vacuum) to 83 per cent at 1.75 lb. per sq. in. (26.44 in. vacuum). The thermal efficiency of the Rankine cycle has also been plotted for comparison with the theoretical thermal efficiency of a constant mean-effective-pressure (or incomplete expansion) cycle having a m.e.p. of 23 lb. per sq. in. This m.e.p. approximates the loading during the tests being discussed. The theoretical thermal-efficiency-ratio line on the diagram shows the effect of incomplete expansion on the efficiency ratio of a constant m.e.p. cycle and illustrates how closely the characteristics of the actual engine conform to those of the ideal.

The form of the efficiency-ratio exhaust-pressure curve in Fig.

TABLE 2 DIMENSIONS OF CLEVELAND'S 12 V.T.E. PUMPING ENGINES AND RESULTS OF 16 OFFICIAL TESTS

Engine	A.C. No. 4	A.C. No. 4	A.C. No. 3	A.C. No. 2	Allis No. 1	Kilby No. 1	Holly No. 1	Holly No. 6	Holly No. 7	Holly No. 2	Holly No. 3	Holly No. 4	Holly No. 5	Kilby No. 1	Holly No. 1	Allis No. 1
Station and Year Installed or Rebuilt	Division 1917		Division 1917	Division 1917	Division 1916	Division 1916	Division 1916	Kirtland 1912	Kirtland 1912	Kirtland 1903	Kirtland 1903	Fairmount 1907	Fairmount 1907	Old Division 1902	Old Division 1902	Old Division 1898
1. Number of steam cylinders	3		3		3	3	3	3		3		3				
2. Diam. of steam cylinders, in.	36–68–108		32–60–96		29.5–58–92	28–54–83	27–52–84	34–64–98		32–60–90		12.75–24–36		30–54–83	30–56–87.5	31–62–92
3. Diam. of piston rods, in.	7¼–7¼–8½		6¼–6¼–8½		6¼–7–7	7¼–7–7	7¼–7–7	8		7.5		2.75		7	7	4¼–4¾
4. Stroke of steam pistons and water plungers, in.	66		66		64	64	48	66		60		24				
5. Net area of h.-p. steam piston, sq. in.	976.6		764.5		651.6	595.1	551.9	882.8		782.2		124.7		687.6	687.6	891.1
6. Net area of i.-p. steam piston, sq. in.	3590		2792		2601	2271	2104	3192		2805		449.4		2271	2488	3002
7. Net area of l.-p. steam piston, sq. in.	9133		7206		6608	5391	5323	7518		6310		1015		5392	5523	6630
8. Proportion of net area of pistons, ratio	1:3.68:9.35		1:3.63:9.38		1:4:10.15	1:3.81:9.06	1:3.81:10.0	1:3.616:8.52		1:3.60:8.11		1:3.60:8.14		1:3.30:7.84	1:3.62:8.03	1:3.37:7.44
9. No. of water plungers (single-acting)	3		3		3	3	3	3		3		3				
10. Diameter of each plunger, in.	31.63		34.75		34	33	22.88	34.75		36		9.875				
11. Area of each plunger, sq. in.	785.5		948.4		907.9	855.3	411.0	948.4		1018		76.59				
12. Displacement of one plunger per revolution, 1000 cu. in.	51.84		62.60		58.11	54.74	19.73	62.60		61.0		1.838				
13. Displacement of three plungers per revolution, 1000 cu. in.	155.5		187.8		174.3	164.2	59.19	187.8		183.1		5.514				
14. Displacement of three plungers per revolution, cu. ft.	90.01		108.7		100.9	95.03	34.25	108.7		106.0		3.19				
15. Displacement of three plungers per revolution, gal.	673.3		812.9		754.6	710.9	256.2	812.9		793.1		23.87		Same as 1916	Same as 1916	Same as 1916
16. No. of valve chambers	6		6		6	6	6	6		6		6				
17. Diameter of each valve chamber, in.	47.25		47.25		63.5	63	47	59.75		59						
18. No. of valves in each cage and no. of cages per deck	28 7		35 7		35 7	35 7	15 4	15 6		15 6		37				
19. Diam. of valve openings, in.	3.25		3.25		3.0	3.0	3.75	3.75		3.75		2.75				
20. Area of valve openings, sq. in.	8.295		8.295		7.068	7.068	11.04	11.04		11.04		3.97				
21. Net area of waterway through set of valves, sq. ft.	8.166		10.21		7.656	7.656	3.39	10.0		10.0		1.020				
22. Ratio of net valve area to plunger area, ratio	1.497		1.55		1.212	1.289	1.189	1.518		1.415		1.918				
23. Diam. of air pump, in.	30		30		28	28	24	24		28		8				
24. Stroke of air pump, in.	66		66		64	48	48	66		60		24				
25. Type of condensers	Surface		Surface		Surf.	Surf.	Surf.	Surface		Jet		Surface		Jet	Jet	Jet
26. No. of condensers	1		1		1	1	1	2		1		1				
27. Diam. of condenser (inside), in.	62		62		62	62	53	60		.....		30.13				
28. No. of tubes in each condenser	700		700		700	700	572	603		.....		135				
29. Inside diam. of tubes in condenser, in.	1		1		1	1	1	0.87		.....		1.00–1.0				
30. Length of tubes in coldensers (between heads), ft.	10.5		8.667		6.959	6.959	7.25	6.417		.....		7.292				
31. Tube surface in condenser, sq. ft.	2200		1800		1450	1450	1100	1762		.....		250				
32. Diam. of main shaft at bearing, in.	20		20		18	18	16	20		17.5		7.5				
33. Diam. of main shaft at flywheels, in.	22.5		22.5		20.25	20.5	19	23.31		20.75		9				
34. Number of flywheels	2		2		2	2	2	2		2		2				
35. Diameter of flywheels, ft.	20		20		20	20	16	20		20		8.5				
36. Diameter of suction pipe, in.	42		48		36	30	30	48		48		14				
37. Diameter of discharge pipe, in.	42		42		36	30	30	42		42		12				
38. Weight of one flywheel, tons	37.5		32.5		32.35	.....	24	38		31.5		3.4				
39. Total weight of engine, tons	950		875		.....	.....	.....	970		970		110				
40. R.p.m. when pumping at rated capacity	20.61		21.35		18.45	19.53	27.10	21.36		21.89		58.18				
41. Piston speed at rated capacity, ft. per min.	226.7		234.9		196.8	208.2	216.8	234.9		218.9		232.7				
42. Piston speed at rated capacity, ft. per sec.	3.778		3.91		3.279	3.47	3.61	3.915		3.65		3.879				
43. Velocity of flow per second, through suction and discharge valves, ft.	1.267		1.262		1.347	1.347	1.52	2.58		2.58		2.022				
44. Velocity of flow ft. per sec. through suction pipe,	3.216		3.077		4.374	4.374	3.15	3.08		3.08		2.895				
45. Velocity of flow ft. per sec. through discharge pipe,	3.216		4.018		4.374	4.374	3.15	4.02		4.02		3.940				

3 is characteristic of the type of engine as well as of the particular unit tested. This characteristic is shown by the tests of seven Cleveland engines plotted in Fig. 4 in which the vacuum varied over a wide range.

The efficiency ratio of the high-pressure and intermediate-pressure cylinders combined, which operate, in effect, as a non-condensing compound, is 83 to 85 per cent, with the high-pressure cylinder alone attaining an efficiency ratio of 90 per cent. These high efficiencies result from the loss, due to incomplete expansion, which is so large in the low-pressure cylinder, being reduced to a minimum for the two higher-pressure cylinders, and from the use of an amount of superheat in the high-pressure cylinder which results in the steam being exhausted at approximately dewpoint.

The bleeding of approximately 8 per cent of the steam used from the second receiver at about atmospheric pressure, and its utilization for heating feedwater, increases the thermal efficiency of the unit approximately 7 per cent and is accomplished with no increase in steam consumption, for the reason that the loss of available energy of 3 per cent in the bled steam is offset by an increased efficiency of the cylinders due to the resulting better distribution of the work between them. This alteration in the efficiency characteristics is better visualized by considering that when the engine is operated without second-receiver bleeding, the intermediate-pressure cylinder is considerably underloaded and the low-pressure cylinder is heavily overloaded and that these conditions of cylinder loading are bettered by the withdrawal of steam from the second receiver for heating purposes.

The performance of the different elements of the steam end

Table 2 (Continued) — Test Data

Engine	A.C.	A.C.	A.C.	A.C.	Allis	Kilby	Holly	Holly	Holly	Holly	Holly	Holly	Holly	Kilby	Holly	Allis
Column	No. 4 1	No. 4 2	No. 3 3	No. 2 4	No. 1 5	No. 1 6	No. 1 7	No. 6 8	No. 7 9	No. 2 10	No. 3 11	No. 4 12	No. 5 13	No. 1 14	No. 1 15	No. 1 16
Date of test	10–14 1918	10–15 1918	10–5 1918	10–10 1918	11–7 1918	11–21 1918	11–15 1918	11–4 1912	11–13 1912	7-20&21 1904	7-13&14 1904	12–13 1907	12–5 1907	12–14 1902	11–7 1902	3–14 1899
Condensate heaters in service	Exh.	Exh., Rec.														
Duration of test, hr.	8	8	8	8	2	2	4	12	12	24	24	12	12	24	24	24 01
Average Pressure and Temperatures																
1. Steam pressure at throttle, lb. gage	206.3	207.1	203.8	208.4	195.8	200.2	199.3	162.9	164.8	149.1	146.8	152.3	149.7	153.9	152.0	149.4
2. Barometric pressure at 70 deg. fahr., in. Hg.	29.61	29.73	29.28	29.59	29.7	29.50	29.6	29.51	28.89	29.24	29.25	28.75	28.95	29.62	29.3	29.68
3. Barometric pressure (corrected to 32 deg. fahr.), lb.	14.48	14.54	14.32	14.47	14.51	14.43	14.48	14.49	14.18	14.38	14.39	14.13	14.20	14.49	14.35	14.52
4. Steam pressure at throttle, lb. abs.	220.8	221.7	218.1	222.8	210.3	214.6	213.8	177.4	179.0	163.5	161.2	166.4	163.9	168.3	166.4	164.0
5. Steam pressure in first receiver, lb. gage	33.7	35.8	34.6	34.0	35.5	38.0	33.3	27.64	27.85	28.24	29.35	26.14	26.13	33.70	25.88	23.86
6. Steam pressure in second receiver, lb. abs.	13.2	11.7	15.8	15.8	13.53	12.71	12.02	10.49	10.34	11.04	10.85	10.95	10.54	14.88	20.05	10.45
7. Vacuum in condenser referred to 30-inch barometer, in. Hg	28.20	28.26	28.43	28.66	28.42	28.67	28.04	27.69	27.27	24.50	24.79	27.10	26.45	26.59	26.44	27.74
8. Temperature of steam at throttle, deg. fahr.	520.6	526.6	503.5	495.6	506.8	499.7	490	493.6	493.6	472.1	464.1	366.7	365.5	367.6	366.7	365.0
9. Degrees superheat at throttle, deg. fahr.	130.4	136.0	114.4	104.6	120.7	111.8	102.5	118.7	117.9	104.6	97.66	none	none	none	none	none
10. Temperature of exhaust steam, deg. fahr.	97.9	94.8	92.6	89.4	93.7	89.0	99.2	105.5	101.4	134.2	135.3	116.4	124	120	121	105
11. Temp. of main condensate entering exh. heater, deg. fahr.	67.4	72.9	70.0	68.9	62.5	60	60					70.73	88			
12. Temp. of main condensate leaving exh. heater, deg. fahr.	94.8	92.8	89.3	86.9	90.4	85.3	96.5					103.9	112.6			
13. Temp. of main condensate leaving receiver heater, deg. fahr.		199.2														
14. Rise of temp. through exhaust heater, deg. fahr.	27.4	19.9	19.31	17.97	27.94	25.3	36.5					33.14	24.6			
15. Rise of temp. through receiver heater, deg. fahr.		106.3														
16. Temp. of jacket and drain water, deg. fahr.	207.9	161.8	210.3	210.9	190.7	211.0	189.9	164.5	161.0	190.2	184.9	189.1	186.8	222.2	183.7	
17. Temp. of water pumped, deg. fahr.	61.5	61.5	61.0	60.0	54	53	53	55	54	73.8	69.5	41.8	42.6	39.6	58	34
18. Water pressure in force main, lb.	167.0	169.9	115.5	114.6	110.7	106.6	168.2	96.89	97.48	73.38	71.46	183.0	180.7	76.87	170.4	85.34
19. Water pressure in suction main, lb.	2.29	3.86	3.42	3.79	6.58	5.78	5.03					6.0	5.63			
20. Elev. of suct. gage above disch. gage ft.	3.09	3.95	3.40	4.32	−7.58	−4.5	−6.25									
21. Disch. head above center line	388.7	393.2	269.5	267.5												
22. Suction head above center line of valve decks, ft.	11.54	16.03	14.14	15.89												
23. Total head pumped against, ft.	377.2	377.2	255.4	251.6	248.0	237.2	382.9	250.5	251.0	194.2	188.9	408.3	404.0	409.1	405.3	202.3
Total Quantities																
24. Total main condensate, 1000 lb.	91.94	82.87	78.06	77.66	14.96	14.29	24.28	123.4	127.5	218.9	210.6	19.76	19.21	190.8	194.9	
25. Total jacket and drain water, 1000 lb.	9.060	17.91	8.840	9.097	1.758	1.613	2.151	12.27	11.71	22.04	22.84	3.189	3.074	27.07	23.31	
26. Total dry steam used by unit, 1000 lb.	101.0	100.8	86.90	86.76	16.72	15.91	26.43	135.7	139.2	238.0	229.7	21.36	22.58	217.0	214.7	212.3
27. Per cent of total steam used by jacket and drain	8.97	17.77	10.17	10.48	10.51	10.14	8.14	9.04	8.41	9.27	9.96	14.31	13.4	14.43	10.87	
28. Total revolutions, 1000 rev.	10.09	10.05	10.35	10.42	2.221	2.148	6.512	15.16	15.94	33.18	32.27	43.12	44.87	29.77	41.75	27.02
29. Water pumped per revolution, lb.	5613	5613	6777	6778	6295	5930	2137	6780	6781	6603	6607	1992	1991	5932	2132	6296
30. Total water pumped, million lb.	56.64	56.39	70.16	70.60	13.98	2.74	13.92	104.8	108.1	219.1	213.2	8.589	8.934	176.6	89.00	170.1
31. Total water pumped, million gal.	6.795	6.765	8.416	8.468	1.676	1.527	1.668	12.57	12.96	26.32	25.59	1.029	1.071	21.16	10.67	20.39
Hourly Quantities																
32. Main condensate per hour, 1000 lb.	11.49	10.36	9.76	9.708	7.481	7.147	6.070	10.29	10.63	9.112	8.775	1.646	1.600	7.950	8.138	
33. Jacket and drain water per hour, lb.	1133	2238	1105	1137	879	806.5	537.8	1022	975.4	919.0	953	265.7	256.6	1128	972	
34. Dry steam used by unit per hour, 1000 lb	12.62	12.60	10.86	10.84	8.36	7.954	6.608	11.31	11.60	9.917	9.571	1.882	1.780	9.060	8.937	8.825
Heat Data																
35. Heat units above 32 deg. fahr. per lb. dry steam throttle, B.t.u.	1275	1278	1267	1262	1269	1265	1260	1264	1263	1262	1256	1194	1194	1195	1195	1195
36. Heat of liquid above 32 deg. fahr. per lb., temp. of jacket and drain, B.t.u.	175.9	129.7	178.3	178.9	158.6	179.0	157.8	154.7	151.3	158.3	153.0	157.1	154.8	192.2	151.7	
37. Heat of liquid above 32 deg. fahr. per lb. main condensate leaving final heater, B.t.u.	62.83	167.1	57.31	54.92	58.4	53.32	64.48	71.53	67.97	72.26	76.31	71.87	80.6			
38. Total heat, units above 32 deg. supplied in steam hr., million B.t.u.	16.10	16.10	13.76	13.69	10.61	10.06	8.327	14.29	14.65	12.51	12.02	2.257	2.150	10.58	10.75	10.20
39. Total heat units above 32 deg. fahr. returned in jacket and drain per hr. 1000 B.t.u.	199.2	290.2	197.0	203.5	139.4	144.4	84.86	158.0	147.5	145.9	146.2	41.91	39.79	215.9	147.9	
40. Total heat units above 32 deg. returned in main condensate per hr. 1000 B.t.u.	7221	1730	5592	533.2	437.2	381.1	391.4	735.8	722.2	650.2	650.2	118.5	129.2	551.7	468.1	
41. Total heat units above 32 deg. returned in jacket, drain and main condensate per hr., 1000 B.t.u.	9213	2021	756.2	736.7	576.6	525.4	476.3	893.8	869.7	796.1	796.4	160.4	169.0	733.4	615.4	

which enters into the characteristics summarized, can be estimated with accuracy from the test data for unit No. 4, and such an examination also discloses the effect of the second-receiver feedwater heater used during the October 15 test. This feature may be of general interest at present because of the attention the subject of stage heating of feedwater is receiving from central-station engineers. The steps followed in analyzing the tests of October 14 and 15, 1918 are described below.

The efficiency ratio of the high-pressure cylinder and jacket is obtainable from the indicated horsepower, the total steam used, the initial steam pressure and superheat and the first receiver pressure, which is the exhaust pressure for that cylinder. The average quality of the steam leaving the high-pressure cylinder and jacket with correction for estimated radiation is therefore known, but because of the arrangement of steam flow in which the condensed steam from the high-pressure jacket is discharged direct to the second receiver without being measured, the quality of the steam in the first receiver is not readily estimated. The high-pressure and intermediate-pressure cylinders' economy is estimated from the sum of their indicated horsepowers, the total steam used, the initial steam pressure and superheat and the second-receiver pressure. As all the steam is brought together again in the second receiver, the quality at this point, with allowance for radiation, is determined with accuracy.

The receiver volumes are very large and they become effective separators, as is evidenced by the large percentage of drain water discharged from the second receiver. An assumption of the complete separation in the second receiver affords a means of estimating the performance of the low-pressure cylinder and jacket, and any error involved in such an assumption has very little effect on computed efficiency ratio.

From the test data of October 15 (including the temperature rise of the condensate through the second receiver heater) the amount of steam withdrawn from the receiver for condensate-heating purposes is readily determined.

The economy of the different cylinders during the October 14 and 15 tests and the distribution of work between the cylinders are given in Table 3, with sufficient detail to illustrate the methods used in arriving at the different results. The results of the analysis of these two tests are also plotted in the form of a Mollier diagram in the complete paper.

The remarkable flatness of the efficiency curve of the vertical triple-expansion type of pumping engine under a great variation of conditions is shown by the curves in Fig. 5, in which the percentage of duty is plotted against variable speed and variable head. The loss in economy is only 5 per cent at half load and 6 per cent at half speed, with flat characteristics on the overload side also.

In view of the high efficiencies attained by this type of unit under all the operating conditions of steam pressure, superheat, vacuum, speed and load, it is felt that some particulars regarding the gen-

TABLE 2 (*Continued*) — TEST DATA

Engine	A.C. No. 4	A.C. No. 4	A.C. No. 3	A.C. No. 2	Allis No. 1	Kilby No. 1	Holly No. 1	Holly No. 6	Holly No. 7	Holly No. 2	Holly No. 3	Holly No. 4	Holly No. 5	Kilby No. 1	Holly No. 1	Allis No. 1
Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
42. Net heat units consumed by unit per hour, million B.t.u.	15.18	14.08	13.00	12.95	10.03	9.536	7.850	13.40	13.78	11.72	11.22	2.096	1.981	9.846	10.14	....
43. Per cent of net units (heat) consumed by jacket and drain water	8.2	18.26	9.25	9.51	9.73	9.19	7.56	8.46	7.87	8.68	7.56	13.44	12.40	11.29	9.99	....
Speed																
44. Revolutions per minute	21.03	20.93	21.57	21.70	18.51	17.9	27.13	21.47	22.14	23.04	22.41	59.89	62.31	20.67	28.99	18.72
45. Piston speed, ft. per min.	231.3	230.2	237.3	238.7	197.4	190.8	217.1	236.2	243.5	230.4	224.1	239.6	249.2	220.5	231.9	199.8
Power																
46. Ft-lb. of work done per hour, million ft-lb.	2670	2659	2240	2220	1734	1510	1332	2188	2260	1773	1678	283.9	300.8	1464	1503	1428
47. Water horsepower	1349	1343	1131	1122	875.5	762.8	672.7	1105	1114	895.7	847.4	147.1	151.9	740.0	759.2	721.5
48. Hydraulic efficiency, per cent	97.98	98.26	....	....	....	....	....	....	....	98.9	95.7	....	....	....	....	....
49. Mechanical efficiency, per cent	97.35	96.47	....	....	....	....	....	....	....	93.85	95.11	....	....	....	....	....
50. Combined hydraulic and mechanical efficiency, per cent	95.38	94.79	96.71	97.48	92.82	85.12	91.24	96.23	96.45	92.69	90.91	95.67	95.70	96.28	96.32	....
51. Average indicated plunger, horsepower	1377	1366	....	....	....	....	....	....	....	906.8	886.4	....	....	....	....	....
52. Average indicated horsepower	1414	1417	1170	1151	943.2	896.1	737.3	1119	1156	966.2	932.0	154.3	158.8	768.0	788.2	....
53. Horsepower lost in mechanical friction	37.53	50.61	....	....	....	....	....	....	....	59.45	45.60	....	....	....	....	....
54. Horsepower lost by water friction, etc.	27.80	23.19	....	....	....	....	....	....	....	11.07	39.05	....	....	....	....	....
55. Total horsepower losses	65.33	73.80	38.5	28.99	67.72	133.3	64.59	13.4	11.8	70.52	84.65	7.22	6.83	28.6	29.0	....
56. Per cent of total i.hp. developed in hp. cylinder	41.14	41.54	42.8	43.05	36.66	37.9	43.70	41.80	41.30	39.72	40.45	35.27	36.33	32.46	37.3	....
57. Per cent of total i.hp. developed in i-p. cylinder	24.08	28.14	25.3	23.47	27.72	23.3	22.65	31.78	32.15	32.63	31.65	32.89	33.64	31.21	34.35	....
58. Per cent of total i.hp. developed in h-p. cylinder	34.78	30.32	31.9	33.48	33.63	38.8	33.65	26.42	26.55	27.65	27.90	31.84	30.03	36.33	28.27	....
Capacity																
59. Rate of pumpage, million gal. per 24 hours	20.38	20.29	25.25	25.40	20.11	18.32	10.01	25.14	25.91	26.32	25.59	2.059	2.142	21.16	10.67	20.35
60. Rated capacity, million gal. per 24 hr.	20	20	25	25	20	20	10	25	25	25	25	2	2	20	10	20
61. Per cent of rated capacity developed	101.9	101.5	101.0	101.6	100.6	91.5	100.1	100.5	103.6	105.3	102.4	102.9	107.1	105.8	106.7	101.8
Economy and Efficiency																
62. Heat units consumed per w.hp.-hr., 1000 B.t.u.	11.25	10.49	11.50	11.55	11.46	12.50	11.67	12.13	12.04	13.08	13.24	14.15	12.87	13.30	13.37	13.55
63. Heat units consumed per i.hp.-hr., 1000 B.t.u.	10.73	9.94	11.12	11.26	10.64	10.64	10.65	11.98	11.92	12.13	12.04	13.53	12.31	12.80	12.88	....
64. Thermal efficiency of entire unit, per cent	22.61	24.27	22.14	22.04	22.21	20.36	21.81	21.00	21.10	19.47	19.23	18.00	19.78	19.14	19.05	18.80
65. Thermal efficiency of steam cylinders, per cent	23.71	25.60	22.89	22.61	23.93	23.91	23.90	21.24	21.35	20.98	21.14	18.85	20.68	19.80	19.78	....
66. Ratio of thermal effy. of unit to that of ideal Rankine cycle	72.78	77.22	70.29	69.27	71.16	64.22	71.17	72.10	73.50	78.20	766	66.1	74.8	69.7	73.5	....
67. Ratio of thermal efficiency of steam cylinders to that of Rankine cycle	76.30	81.46	72.63	71.06	76.61	75.43	77.99	73.0	74.4	83.3	81.2	69.2	78.2	72.5	76.3	....
68. Pounds of steam consumed per w.hp.-hr., lb.	9.36	9.38	9.60	9.67	9.55	10.43	9.82	10.23	10.14	11.07	11.29	12.75	11.71	12.23	11.72	11.81
69. Steam consumed per i.hp.-hr., lb.	8.93	8.89	9.29	9.43	8.86	8.875	8.96	10.11	10.03	10.26	10.27	12.20	11.21	11.77	11.34	....
Duty																
70. Ft-lb. of work per million heat units	175.9	188.7	172.2	171.4	172.8	158.4	169.7	163.3	164.5	151.4	149.6	140.0	153.9	145.9	151.2	146.0
71. Ft-lb. of work per 1000 lb. steam, million ft-lb.	211.5	211.0	206.2	204.8	207.4	189.9	201.6	193.5	193.4	178.8	175.4	155.5	169.6	162.0	168.2	167.4
72. Duty per million B.t.u. correct. per test curves, million ft-lb.	173.8	186.0	171.3	171.1	....	....	....	....	....	....	....	....	....	....	....	....
73. Duty per million B.t.u. correct. per Rankine cycle, million ft-lb.	172.9	184.8	170.4	171.0	....	....	....	....	....	....	....	....	....	....	....	....
74. Guaranteed duty per million B.t.u., million ft-lb.	170.0	....	170.0	170.0	....	....	....	....	....	....	....	....	....	....	....	....

eral features of cylinder construction and arrangement, the type of valve gear, and the system of steam flow through the engine will be found of interest.

The steam cylinders are jacketed, a jacket for each being supplied with steam at the initial pressure for that cylinder.

The high-pressure cylinder has Corliss admission and exhaust valves. The intermediate-pressure cylinder has Corliss admission valves and single-beat poppet exhaust valves. The low-pressure cylinder has single-beat poppet admission and exhaust valves. The valves for all cylinders are located in the cylinder heads with the poppet valves flush with cylinder-head surface when closed. The types of steam and exhaust valves used, Corliss and single-beat poppet, insure tightness when good workmanship and a detailed design that minimizes distortion under temperature changes are employed. The location of all steam valves in the cylinder heads reduces the cylinder clearance to a minimum, as may be judged from an inspection of Table 4.

The slow speed and great dimensions of the steam cylinders and receivers result in the exposure of a large cylinder and receiver surface per 1000 lb. of steam used, but as a result of the thorough covering with a high-grade non-conducting material and the enclosing sheet-metal lagging, the loss of radiation is very small. An estimate of this loss, using generally accepted coefficients of heat transmission, indicates that not more than 1 per cent of the total steam is condensed by radiation.

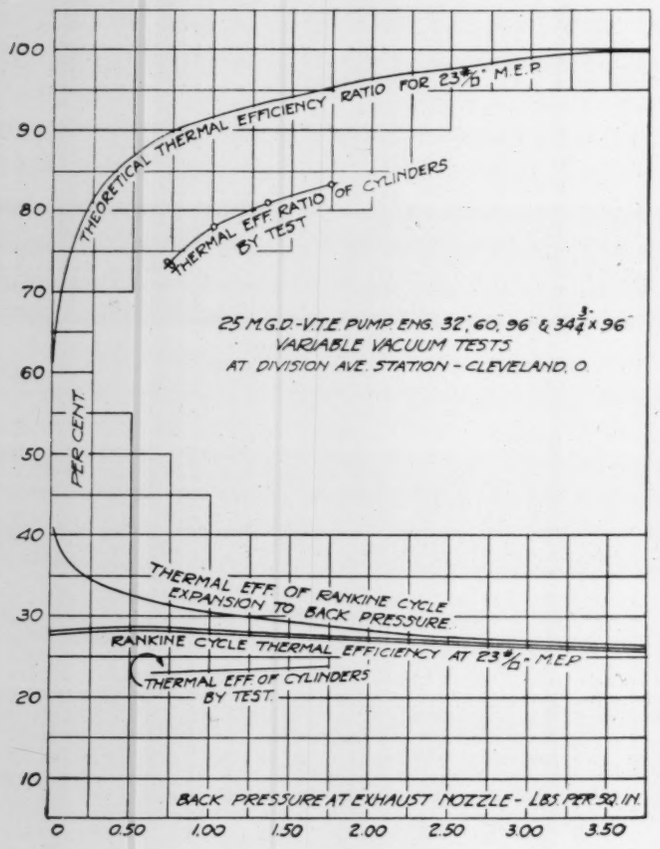

Fig. 3 Variable Vacuum Tests at Division Avenue Station, Cleveland, Ohio

The condensed steam from the high-pressure cylinder jacket is discharged through a trap to the second receiver space. The condensate drain from all the first receiver spaces and from the intermediate-pressure cylinder jacket is likewise discharged through a trap to the second receiver. All of the condensed steam from the second-receiver low-pressure cylinder jacket, and the second-receiver feedwater heater, when it is in service, is discharged through a single trap to atmospheric pressure. The temperature of the water thus discharged to the atmosphere does not at any time exceed 200 deg. fahr.

The steam exhausted from the low-pressure cylinder is condensed in a water-works type surface condenser (the steam flowing through the condenser tubes in two passes) located in the main suction pipe directly adjacent to the pump chambers.

The condensate is removed from the condenser by a single-acting bucket-type wet air-pump driven direct from the low-pressure plunger head and discharges into a tank from which it is pumped through the exhaust-steam heater to the station feedwater heater by a single-acting condensate pump direct driven from a main-pump plunger-head. The exhaust-steam heater is located in a by-pass connection of the main exhaust pipe just ahead of the condenser.

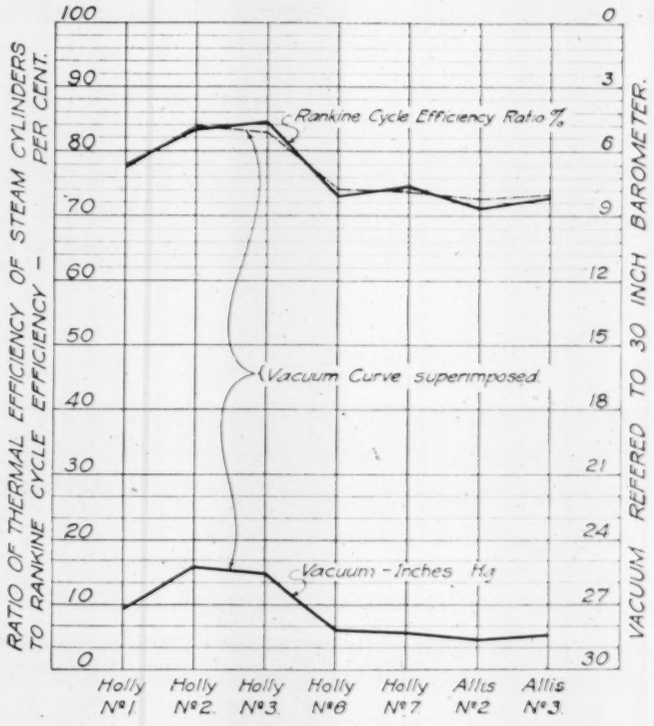

Fig. 4 Variation of Rankine-Cycle Efficiency Ratio with Vacuum on Seven Different Engines

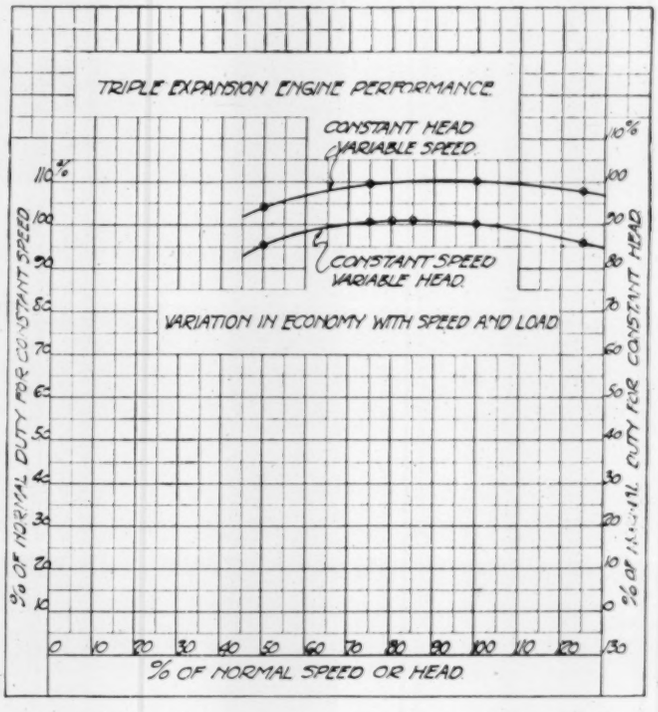

Fig. 5 Triple-Expansion-Engine Performance: Variation in Economy with Speed and Load

TABLE 3 ECONOMY ANALYSIS OF NO. 4 UNIT, DIVISION AVENUE STATION
(Cylinders 36 in., 68 in. and 108 in.; stroke 66 in.)

	Oct. 14	Oct. 15
Test date (1919)		
Steam pressure, lb. abs.	221	222
Superheat, deg. fahr.	130	136
1st receiver pressure, lb. abs.	48.2	50.4
2d receiver pressure, lb. abs.	13.25	11.71
Exhaust pressure lb. abs.	0.885	0.855
ENERGY AVAILABLE, RANKINE CYCLE:		
To entire engine, B.t.u. per lb.	378	381
To high-pressure cylinder, B.t.u. per lb.	132.5	130.5
To high- and intermediate-pressure cylinders, B.t.u. per lb.	224.5	234.5
To low-pressure cylinder, dry steam initially, B.t.u. per lb.	169.5	163.0
To low-pressure cylinder theoretically, B.t.u. per lb.	153.5	146.5
INDICATED HORSEPOWER:		
Entire engine	1417	1420
High-pressure cylinder	582	590
High- and intermediate-pressure cylinders	924	990
Low-pressure cylinder	493	430
PERCENTAGE OF POWER PER CYLINDER:		
High-pressure cylinder, per cent	41.14	41.50
Int.-pressure cylinder, per cent	24.08	28.14
Low-pressure cylinder, per cent	34.78	30.32
STEAM WITHDRAWN FROM SECOND RECEIVER FOR HEATER:		
Temp. rise of condensate through heater, deg. fahr.		106.3
Latent heat at 2d receiver pressure, B.t.u. per lb.		977
Calculated refrigeration of condensed steam in heater, deg. fahr.		100
Heat given up in heater per lb. supplied, B.t.u.		1077
Condensate pumped through heater, lb. per hr.		10,359
Heat absorbed by condensate, B.t.u. per hr.		1,100,000
Weight of steam supplied heater from receiver, lb. per hr.		1020
Weight of steam from 2d receiver, low-pressure cylinder jacket and receiver heater, lb. per hr.	1133	2238
Weight of steam from 2d receiver and low-pressure cylinder jacket, lbs. per hr.	1133	1218
Weight of condensate from condenser, lb. per hr.	11,492	10,359
ECONOMY OF HIGH-PRESSURE CYLINDER:		
Weight of total steam supplied high-pressure cylinder, lb. per hr.	12,625	12,597
Steam used per i.hp-hr., lb.	21.70	21.35
Efficiency ratio	0.885	0.915
Average quality at exhaust of high-pressure cylinder and jacket, including radiation	0.9817	0.9827
ECONOMY OF HIGH- AND INTERMEDIATE-PRESSURE CYLINDERS:		
Weight of total steam supplied cylinders, lb. per hr.	12,625	12,597
Steam used per i.hp-hr., lb.	0.830	0.853
Average quality at exhaust of cylinders in 2d receiver, including radiation	0.9325	0.9234
ECONOMY OF LOW-PRESSURE CYLINDERS:		
Weight of total steam entering 2d receiver, lb. per hr.	12,625	12,597
Average quality of steam in receiver, including radiation loss, lb. per hr.	0.9325	0.9234
Moisture discharged from receiver, assuming complete separation, lb. per hr.	852	966
Dry steam withdrawn by receiver heater, lb. per hr.		1020
Net dry steam supplied low-pressure cylinder and jacket, lb. per hr.	11,772	10,612
Dry steam used per i.hp-hr., lb.	23.9	24.65
Efficiency ratio of low-pressure cylinder	0.628	0.634
Calculated weight of steam supplied cylinder jacket, lb. per hr.	280	253
EFFECT OF SECOND RECEIVER HEATER:		
Total steam used by high- and intermediate-pressure cylinders, lb. per hr.	12,625	12,597
Energy available to high- and intermediate-pressure cylinders, B.t.u. per lb.	224.5	234.5
Dry steam withdrawn for 2d receiver heater, lb. per hr.		1020
Total steam used by engine from 2d receiver, lb. per hr.	12,625	11,577
Theoretical quality in 2d receiver	0.900	0.887
Theoretical energy available to low-pressure cylinder, B.t.u. per lb.	153.5	144
Theoretical total energy available to engine	47,800,000	46,280,000
Difference in energy available between tests resulting from use of receiver heater and from different steam conditions, per cent		3.18

DISCUSSION OF PAPER ON VERTICAL TRIPLE-EXPANSION PUMPING ENGINE

AS SUPPLEMENTARY data Leonard A. Day[1] submitted the results of a more recent test on the Holly engine at Bissell's Point Station than that referred to in Table 1. The duty in ft-lb. per B.t.u. was 166.7, and this was raised to 169.3 by installing an exhaust heater. Assuming the ratio of the thermal efficiency of the unit to that of the ideal Rankine cycle not to vary for an increase in the steam conditions from those in the test to those of A. C. pump No. 4 of the Cleveland tests, then the increase in duty would be in direct proportion to the increase in the Rankine-cycle efficiency, an increase of 4.8 per cent. The resultant duty would be $169.3 \times 1.048 = 177.5$, or a duty comparable with that of the Cleveland A. C. pump No. 4. The overall thermal efficiency of the unit including exhaust heater is 21.8 per cent for the steam conditions of the test, and 22.8 per cent for the steam conditions of A. C. pump No. 4 of the Cleveland tests.

TABLE 4 AVERAGE CYLINDER CLEARANCES, DIVISION AVENUE UNIT NO. 4

Cylinder	Diameter, inches	Stroke, inches	Cylinder clearance volume, per cent of piston displacement
High-pressure	36	66	1.50
Intermediate-pressure	68	66	0.50
Low-pressure	108	66	0.25

E. E. Miller[2] said that some years ago he plotted a temperature-entropy diagram from an Allis-Chalmers engine in St. Louis during one of the official tests, which showed up very clearly the loss due to expansion in the low-pressure cylinder: that is, the fact that it could not be carried out as far as they would have liked to carry it out, as mentioned in the paper.

A. G. Christie[3] said that he did not believe any turbine-driven centrifugal pump could approach the 77 per cent overall Rankine-cycle efficiency given in item 66 of Table 2 for the Allis-Chalmers No. 4 pumping engine. Recently, at one of the largest pumping plants in the country he had seen an engine that had not been overhauled for extensive repairs since it was first put into service in the 70's. He doubted whether a turbine installation would operate for a similar length of time without rebuilding and considerable renewal of parts.

In reply to a question put by the chairman of the session, Past-President Jacobus, George A. Orrok[4] said that reciprocating engines and exhaust-steam turbines could be combined so as to give remarkably good results. The cost, however, would be another matter. The proposal had been made to put in a reducing gear between the turbine and the pump, and while in naval practice the reduction gear was said to be giving satisfactory service, there were nevertheless some who did not quite fancy its employment.

By and large, he would say that the best efficiency in pumping water would be gotten out of a reciprocating engine with the proper arrangement for using the heat in the receiver. As to money economy, that was different. Large pumping engines now cost from 8 to 8.5 cents per lb. and turbines all the way from 50 cents to 82 per lb. While ordinary centrifugal pumps cost about the same as engines, those of an efficiency approaching 90 per cent would probably cost from 25 to 30 cents per lb.

Referring to the paper, he regretted that the author had employed the Mollier diagram to show the performance of the engine instead of the better and simpler temperature-entropy diagram.

Frank L. Fairbanks[5] asked what the drop in efficiency of large-size water-works centrifugal pumps would be in a given period. He had had experience with centrifugal pumps in pumping refrigerating brines and salt water and knew that in such work the efficiency held up less than six months and that the average life of an impeller in salt water was less than a year. At Buffalo tests showed that in less than 18 months the drop was prohibitive, and in putting in new equipment the water-works company went back to the reciprocating type of equipment.

George H. Gibson,[6] replying to Mr. Fairbanks said that two large

(Continued on page 176)

[1] Engr. in Charge Operating Section, Water Div., 34 E. Grand Ave., St. Louis, Mo.

[2] Asst. Supt., Power Plants, Hackensack Water Co., Weehawken, N. J.

[3] Prof. M. E., Johns Hopkins Univ., Baltimore, Md.

[4] Cons. Engr., New York.

[5] Ch. Engr., Quincy Market Cold Storage & Warehouse Co., Boston, Mass.

[6] 70 Oakwood Ave., Upper Montclair, N. J.

Conservation of Timber Supply

Addresses Delivered at the A.S.M.E. Annual Meeting and Dealing with Reforestation for the Purpose of Community Perpetuation, and the Manufacture of Paper and By-Products from Southern Pine Refuse

TWO important phases of the problem of conserving the timber supply of the country were discussed at the Forest Products Waste Session of the A.S.M.E. Annual Meeting in December, Thomas D. Perry presiding. David L. Goodwillie, chairman of the U. S. Chamber of Commerce Committee on Conservation and Reforestation, gave details of the reforestation plans that had been followed out at Bogalusa, La., whereby a continuous supply of stumpage is insured that will furnish the raw material needed to keep the industries of the town in active operation.

Mr. Goodwillie was followed by Joseph H. Wallace, of the firm of Joseph H. Wallace & Co., Industrial Engineers, New York City, who spoke on the wasteful methods that had hitherto obtained in the resinous pine districts of the South—and the particularly harmful practice of tapping turpentine from the living tree thereby probably causing its death—and told of a combination of processes involving distillation, extraction and paper making that had been developed and put into successful operation, whereby every part of the stump and logging refuse can be utilized in an efficient manner. The texts of these two interesting addresses immediately follow.

Reforestation to Conserve Industrial Investments

By DAVID L. GOODWILLIE,[1] CHICAGO, ILL.

REFORESTATION for the purpose of perpetuating our timber supply for future generations, for enhancing the beauty of our landscapes, for insuring a continuous supply of lumber for commercial uses and for preventing the denuding of lands and the consequent deterioration of their reproductive qualities, are well-known appeals of substantial merit.

EXAMPLE OF LONG-LEAF YELLOW PINE FROM 3 TO 10 YEARS OLD, FENCED ABOUT 10 YEARS; NATURAL REPRODUCTION

The perpetuation of the timber supply for the purpose of conserving industrial and municipal investments is a new and forceful argument that is well exemplified by the far-seeing plans of the Goodyear interests at Bogalusa, Louisiana. Some sixteen years ago a man of vision, W. H. Sullivan, pitched a camp in the woods and as his vision crystallized into accomplishment, there grew the sawmill of the Great Southern Lumber Co., and the New Orleans, Great Northern Railroad connecting this sawmill with the market. A little later the Bogalusa Paper Company came into being, converting much of the sawmill and stump-land waste into Kraft paper and pulp board.

In addition to the foregoing is a hardwood sawmill, a veneer mill, many miles of logging road and other associated and affiliated industries.

The visions of the founder of Bogalusa were clear enough to foresee the time when all of the above mentioned industrial developments, together with the homes and cottages, paved streets, parks, hotels, clubs, schools and churches, would disintegrate into a pine barren if proper provisions were not made for a continuing supply of stumpage that would furnish raw material to keep the wheels of Bogalusa's industries turning.

It has been one of the undisputed principles of American existence that until visions are entrenched behind economic facts they seldom materialize into actual accomplishments. A realization of this caused the Goodyear interests under the leadership of W. H. Sullivan, manager of the Great Southern Lumber Co., to begin early to solve, first, the problem of protecting the native seedling on cut-over lands from fire and hogs, and second, the best method of planting new varieties of trees. This was followed by experiments in transplanting both the nature-sown and hand-sown product, to determine how to produce merchantible lumber quickly. The result is seen in the twelve- and fourteen-year stands of pine shown in the accompanying illustrations where the young trees are approaching a point of usefulness for paper making and giving promise of merchantible sawmill timber in thirty to fifty years, according to variety.

"The growth of the most rapidly growing seedling tree," says Mr. Courtenay DeKolb in a recent article, "averages about half an inch in diameter per year, producing a four-inch tree in eight years, a fifteen-inch tree in thirty years, and a twenty-inch tree in forty years. During the period from germination to the eighth year the lands may be profitably occupied in grazing. It will take 30 years for most of the lumber companies on our line to cut out the present virgin tree crop, and by that time our fifteen-inch second-growth trees will be ready for the saw, thus insuring an uninterrupted continuation of our great wood industries."

The method of encouraging nature in her seed scattering is interesting. "Preceding the axe and saw," continues Mr. DeKolb, "goes the forestry man, and he selects and rings in white paint, at least three good seed trees to the acre. These marked trees are spared and preserved as the progenitors of our future forests. The undersize trees left by the sawmill make good pulp wood to start with. Under their genial sun, ample rain and almost uninterrupted growing season, the new growth comes along, and in eight years the land is ready to be culled for wood for pulp, leaving the extremely promising trees for lumber. Thus judicious thinning of the trees for pulp wood goes on until 75 or 80 excellent lumber trees are left on the acre."

Another incentive to tree culture, according to Walter S. Ayres, is being held out by a wise statute enacted in Louisiana which enables any one owning land suitable for reforestation and assessed at a valuation not in excess of $10 per acre to enter into a contract

[1] Chairman, U. S. Chamber of Commerce Committee on Conservation and Reforestation.

with the state for periods ranging from 15 to 40 years, as desired, whereby the landholder obligates himself to reforest under the general advice and direction of the Forestry Division of the State Department of Conservation, and the assessment valuation of such land then remains fixed during the period of the contract.

"Many years ago," says Mr. Ayres, "Louisiana enacted a law that should serve as a model for every Southern state. It permitted a reforestation contract that automatically fixed the valuation of such land at $1 per acre for the period of the contract up to 40 years. This law was in advance of the times and comparatively few took advantage of it. Among those who were wise enough to do so was Henry E. Hardtner of Urania. As the liberality of this statute was not appreciated, it was modified so that now the average fixed valuation under such a reforestation contract is $5 per acre. This is rather high. A return to the $1 basis would be better, accompanied by a soil survey when application for exemption is made, so that it should apply to lands more valuable for tree culture than for general farming."

The demonstration has gone far beyond the experimental stage, and has proved adequately that the obliteration of sawmill towns at the expiration of the cutting of virgin timber is an industrial waste that has no justification in the economics of modern life and the conservation of natural resources.

A wealth of useful information on the kinds and varieties of pine trees best suited to protection, planting and transplanting is now available and the harder and rugged varieties are known and used. The present worth of the millions invested in the industrial development of Bogalusa have increased over 50 per cent by the practical demonstration of these plans for perpetuating its raw-material supply.

We Americans are conspicuous for our wonderful visions, but we seldom reduce these visions to as useful or practical a plan as is evidenced in what the Goodyear interests have done at Bogalusa.

PROGRESS OF REFORESTATION BY NATURAL SEEDING; THE YOUNG TREES ARE SEEDLINGS FROM THE PARENT TREES SEEN IN THE PICTURE

Paper and By-Products from Southern Pine Refuse

BY JOSEPH H. WALLACE,[1] NEW YORK, N. Y.

THE lumberman and naval stores operator have been for years destroying the resinous pines of the South with reckless extravagance. Only about one-third of the tree ever reaches the market in the form of lumber, lath, or shingles, while a few years of the wasteful American methods of tapping turpentine from the living tree are sufficient to cause its death.

For three-quarters of a century engineers, chemists, and business men have endeavored to devise means to unlock this storehouse of wealth. This effort of inventive genius has been directed along three distinct lines. The first to be undertaken was the destructive distillation of the stump and trash wood. This produced tar, pitch, and charcoal having sufficient value to offset a portion of the cost of clearing the land. These processes have recently developed and have become moderately profitable, particularly on account of the value of flotation oils for use in the mining industry.

The second scheme for reclaiming this wealth was the cutting of the wood into fine chips, then steaming them in a closed vessel under sufficient pressure to distill off the turpentine—the steamed wood then being dried and used for fuel. This became profitable when it was found that after steaming, the wood could be used as a source of supply of rosin by extraction with a solvent. This modified plan, known as the "steam and solvent process," is now operated successfully in many locations.

The third proposal was an undertaking to utilize the fiber of the wood for making pulp and paper. This could be done only with difficulty by the acid pulp methods common to the industry, because of the extremely resinous nature of the wood.

These three methods, each commercially successful, do not recover a large percentage of the potential wealth of the stump and logging waste. Both the destructive distillation and the steam and solvent methods result in the destruction of the fiber, on which the pulp and paper manufacture depends, whereas, the value of the fiber is as great as that of all the other products.

The above methods for utilization of this material have been combined in a well-balanced combination of processes, which will utilize every part of the stump and logging refuse in an efficient manner.

A preliminary treatment will take place in semi-portable field plants which will produce turpentine, pine oil, rosin, pyroligneous acid, and tar—as well as a main product—pulp chips, of a uniform moisture and resin content.

Pulp and paper plants may be located where manufacturing and labor conditions are most favorable and where conditions justify large outlay of capital investment.

At the field plants the chips will be sorted into—

a Material suitable for pulp making

b Material physically unsuitable for pulp making, either because of partial decay or containing too much knot or imperfect material, and including bark, sawdust, etc.

The material unsuitable for pulp manufacture (termed "trash") will be used as raw material for destructive distillation, producing in addition to the usual acid, flotation oils, etc., a fuel supply sufficient for all of the requirements of the field plant.

No more complicated apparatus is required than is found in the average sawmill, and no labor more skilled. The method involves only the performance of work. Turpentine, pine oil, and rosin of high grade are extracted from the pulp chip before it is delivered to the pulp mill, and incidentally the character of the main product, the chip, is so modified as to make it a new article—a Standardized Chip. A chip that is uniform in rosin content, acid content, and moisture content is now available for the first time in the history of chemical pulp manufacture. The use of a standardized material for pulp making will result in increased yield, and a superior quality and uniformity of pulp.

The average yield per acre of cut-over Southern pine lands in East Texas as determined by numerous surveys, is

7½ cords pulp wood

4½ cords trash wood.

As a result of the combined operations now proposed, and by methods hereinafter described, each acre of stump and woodlands cleared has a potential wealth shown in Table 1.

[1] Joseph H. Wallace & Co., Industrial Engineers.

Table 1 is based on actual quantities shown to be commercially available from material cleared from a typical acre of cut-over pine land, and on the average value of the products during the first half of 1921.

In taking a bird's-eye view of this prospective empire of industrial development, the thought naturally occurs that there are eleven competitive areas, each with an outlet through a deep-water port,

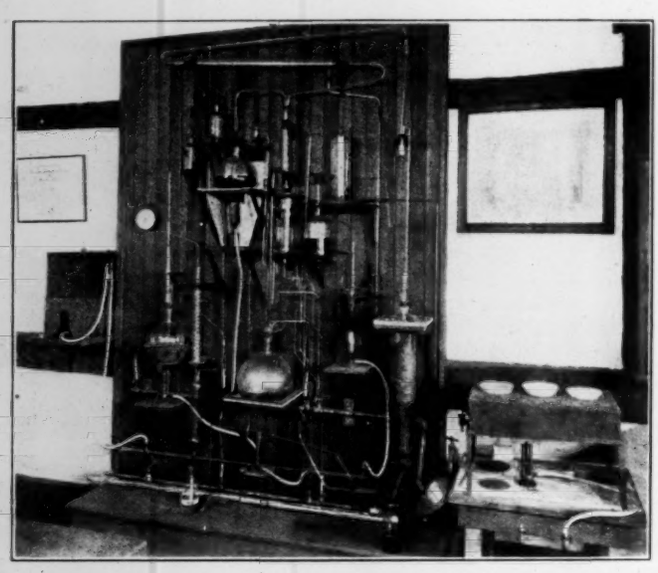

Fig. 1 Laboratory Extraction and Refining Plant

viz., Wilmington, N. C., Charleston, S. C., Savannah and Brunswick, Ga., Jacksonville and Pensacola, Fla., Mobile, Ala., Gulfport, Miss., New Orleans and Lake Charles, La., and Beaumont, Sabine or Galveston, Texas.

The project under consideration contemplates a preliminary treatment of material at or near the point of its origin for the extraction of by-products of a non-cellulose character, and it is believed that the cost of preparing the material for paper making, including the extraction of resinous material, would be commercially justified without regard to the utilization of trash wood or the land values necessarily increased by the removal of the wasted material therefrom.

TABLE 1 VALUE OF PRODUCTS ON AN AVERAGE ACRE OF CUT-OVER PINE LANDS IN THE SOUTHERN STATES

Pulp and Paper Plants		
Kraft, 3,125 tons at 120 ($7\frac{1}{2}$ cords, 4.18 tons of paper per cord)		$375.00
Extraction Plant		
Turpentine, 49.2 gal. at $0.60 (6 cords, 8.2 gal. per cord)	$29.52	
Pine Oil, 40.8 gal. at $1.48 (6 cords, 6.8 gal. per cord)	60.38	
Rosin, 9.9 bbl. at $5.83 (6 cords, 1.65 bbl. per cord)	57.72	
		147.62
Distillation Plant		
Turpentine, 18.0 gal. at $0.57 (3 cords, 6.0 gal. per cord)	$10.26	
Pine Oil, 12.9 gal. at $1.30 (3 cords, 4.3 gal. per cord)	16.77	
Tar Oils, 6.19 gal. at $0.275 (3 cords, 2.73 gal. per cord)	1.70	
Pitch, 1755 lb. at $0.0395 (3 cords, 585 lb. per cord)	69.32	
		98.50
Total per acre		$620.67
Fuel and Solvent[1]		

[1] Values not incuded.

The locations for wood-preparing and extraction plants must have—

1 Suitable water supply
2 Transportation
3 Convenience to territory to be cleared and to existing sawmills.

By locating field plants at sawmill locations, the operations will be assured of large amounts of pulp material from slabs, edgings, etc., while the scheme for land development is under way.

Because of great variation in the oleoresin content there is much of the pine waste which cannot be profitably exploited either by destructive distillation or by extraction, but which can be economically converted into pulp. On the other hand, a considerable portion of the stumps and other pine waste, while rich in resin, is so damaged by fire and rot as to be unfit for use either in the pulp mill or extract plant. Fibers that are scorched or decayed are too weak to make good pulp, and the charcoal adhering to burnt wood darkens the color of the rosin obtained by extraction, making this product less valuable. There exist three classes of wood corresponding to the three methods of utilization:

1 Charred and rotten wood fit only for destructive distillation
2 Lean wood good for pulp but not profitable for extraction
3 Fat lightwood, rich in oleoresins, a good raw material for the steam and solvent process.

By a suitable coördination of the extraction with the pulping operation in which the latter assists in the recovery of solvent, it becomes possible to overcome the difficulty in extracting pulp-size chips, and to obtain both oleoresins and paper pulp from the fat lightwood. This combination answers the requirements set forth

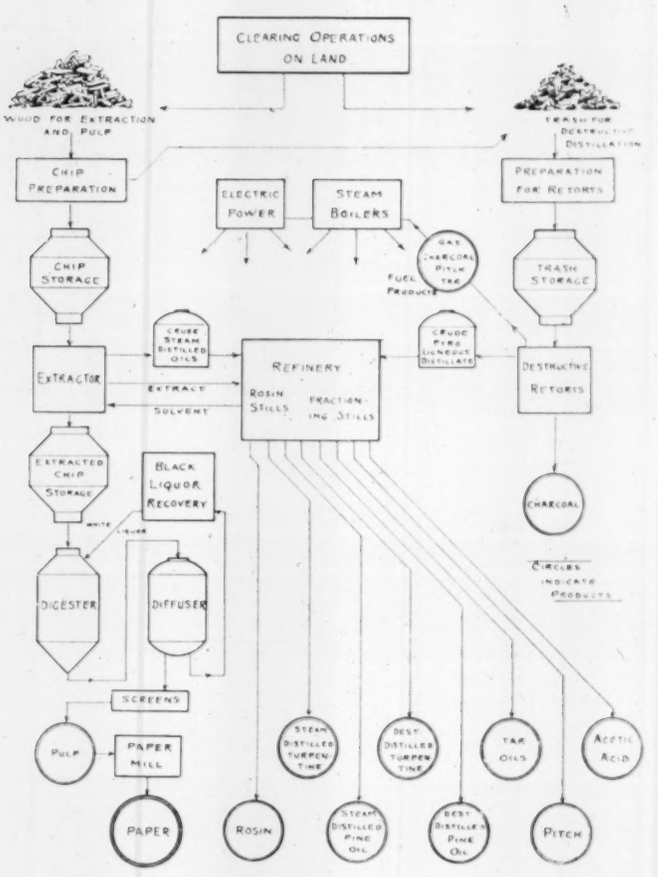

Fig. 2 Diagram Showing Manufacture of Pine Products from Waste of Cut Over Lands

above. Pulp manufacture is the main object, and any additional revenue derived from the oleoresin products is pure "velvet."

One great advantage in choosing pulp and paper as the main product lies in the fact that this material can be sold on a generally stable market, while the naval stores market is notoriously speculative. So little capital is required to engage in turpentine operations that any rise in prices is quickly followed by an influx of small-scale operators, resulting in overproduction to the detriment of the trade.

In the experimental research work on the yellow-pine refuse, a miniature extraction and refining plant was first constructed from standard pieces of laboratory glassware, substantially as shown in Fig. 1.

After several modifications resulting from actual operation of this miniature plant, the process was sufficiently perfected to warrant tests on a larger scale. Accordingly a semi-commercial mill was built alongside the laboratory.

As a result of a series of tests in this miniature mill, the processes and methods mentioned have been thoroughly demonstrated.

Stresses and Deformation in Flat Circular Cylinder Heads

By GILBERT DUDLEY FISH,[1] NEW YORK, N. Y.

An analysis covering homogeneous elastic disks, where form and loading are symmetrical with respect to all diameters, where the loading is a combination of fluid pressures and of forces acting normally on concentric circles, where the thickness is uniform, and where all strains are within limits of true elasticity. Formulas applicable to all cases considered in the paper are developed, and equations are given for the constants of integration involved in the mathematical analysis. Two typical cases of the application of the principles involved have been analyzed and the results presented diagrammatically. To facilitate the computation of critical stresses and deflections in cases commonly occurring, simplified formulas are presented which may be solved by the use of charts from which certain terms are derived.

THIS paper is a mathematical analysis of stress and strain, and contains no discussion of the merits of the physical laws on which it is based. It adopts the conception of internal stress as a dependent function of strain, quite distinct from internal force which follows the laws of equilibrium; it considers that internal stress, as distinguished from internal force, is the criterion for resistance.

The field in which this analysis is intended to be useful is the design of large cylinder heads to withstand high pressures. Boiler practice, dealing with light plates and moderate pressures, provides no formulas or other guides which may be used properly in cases of pressures as high as one ton to the square inch, or of heads one foot or more in thickness. The futility of applying empiric formulas or other approximations of unknown latitude, in the design of a cylinder head which is to cost thousands of dollars, and the failure of which might cause immense damage, becomes apparent when it is discovered that in many familiar cases the values of critical stress, as given by various commonly employed methods or formulas, run as low as one-half or as high as double the values obtained by rigorous analysis.

A feature of this analysis which is thought to be of special importance is the treatment of a cylinder head having a central hole. Such a hole, even if small, has a tremendous effect on the critical stress.

While the study of the elastic deformation of a head is necessary preliminary to the determination of stresses, it is not for this reason alone that the analysis of deformation is important; the effectiveness of a gasket, depending as it does on residual gasket load, is directly related to the deflections of the head at the gasket circle before and after application of the working pressure.

It is thought proper to answer in advance an objection which may be raised against the formulas resulting from this analysis. In case it be attempted to check some of the stress formulas, by using them to calculate the maximum intensity of tensile or compressive stress in a plate or cylinder head which is known to have failed under a certain loading, a highly erroneous result is to be expected. This analysis is confined to the conditions existing in a body which is not strained beyond the limit of true elasticity at any point. The physical laws connecting strains and forces are not even approximately true outside the limits of elasticity, and the internal stresses, unlike those in a simple beam, are dependent on deformation. Therefore this analysis does not yield formulas whereby the ultimate resistance of a disk may be predicted. It is important that the strains in any cylinder head should not exceed the limits of elasticity, and it is consequently not essential to know what loading would cause it to crack or burst. In design, there must be established limiting intensities for stresses of tension, compression and shear, all well within the respective limits of elasticity for the material at whatever temperatures may be expected.

While it is not within the scope of this paper to make recommendations in regard to practice, it is thought proper to discourage the use of the ultimate strength of a material (whether in respect to tension, compression or shear) as a criterion for the maximum permissible stress in practice. Either the elastic limit or the fatigue limit is preferable as a criterion, especially in case of a special alloy steel or other material for which there exists no standard practice in regard to working stresses.

Attention is invited to the relatively large effect of detrusive (shearing) strain on the deformation of a thick head. Whereas, in the case of a boiler head, the deflections due to detrusive strain are minute in comparison with those due to flexure, they may even exceed those due to flexure in the case of a cylinder head designed to withstand several tons to the square inch, especially if there be a hole through the head.

Reference is made to the mathematical treatment of flat circular plates, by Prof. F. Grashof of Carlsruhe, published in his Elastizität und Festigkeit. There is believed to be no flaw in his analysis, and the present study, originally made without reference to his work and from a somewhat different method of approach, gives results identical with his, in so far as the same ground is covered by both. However, modern industrial apparatus involves conditions quite different in degree, if not in principle, from those contemplated by Professor Grashof, so that his formulas cannot, without a great deal of mathematical work, be extended so as to apply to actual cylinder heads. For example, it is necessary to analyze shear deflection, which was of no importance when pressures did not exceed a few hundred pounds to the square inch. Again, in the case of high pressure, surface application of load, as contrasted with distribution of load throughout the mass, appreciably reduces compressive stresses and deformation, and should be considered. The only special cases for which Professor Grashof published resulting formulas (i.e., formulas which can be used by direct substitution of numerical data), are very elementary cases which are never even approximately realized in the type of apparatus here considered. It will be found, therefore, that only a small part of this analysis is concerned with ground already covered in the work referred to. If part or all of the remainder duplicates anything previously published, the author can only plead ignorance.

Preliminary Explanation

Hooke's law, and Poisson's principle of constant ratio between lateral and longitudinal strains, are used as bases for this analysis. It is further presupposed that the elastic properties of the material are the same at all points and in all directions; also that elements (lines of particles), which in the absence of strain are straight and normal to the neutral surface, do not suffer curvature or obliquity due to flexure within the limits of elasticity, but do become curved and oblique to the neutral surface due to detrusion alone.

To define the general case to which this analysis is applicable, the initial presumptions are set down as follows:

a The head is of uniform thickness throughout

b The head is simply and uniformly supported around a circle.

The familiar case of fastening by means of bolts, closely and uniformly spaced around a bolt circle, there being clearance between head and flange, is nearly a perfect realization of this assumption, except in respect to the unimportant direct stresses near the bolt circle; the shearing stresses at the bolt-circle section, which may be critical, are closely approximated by the formulas if the bolt-hole area be deducted from the gross area of the section. The design of a cylinder head may sometimes suggest fixation of the head at the support, as in the case of a head bolted tightly against a flange; however, in high-pressure work such fixation cannot actually exist, for no bolts are so inextensible as to prevent the slight angular strain which destroys fixedness, although a small degree of restraint may be imposed. Therefore fixed heads are ruled out of considera-

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tion as non-existent in fact, although it is not difficult to analyze the stresses and strains which would exist in such heads. Partially fixed heads are also excluded, for one reason because it is not possible to estimate the degree of fixedness in any given case, and for the other reason because such manner of support is considered bad practice, there being no known means for combining it with a gasket or other device so as to make a joint tight against high pressure.

c The head may be solid (i.e., have no perforations other than bolt holes); but, if not solid, it has only a single central hole of uniform circular bore, concentric with the bolt circle. If there be

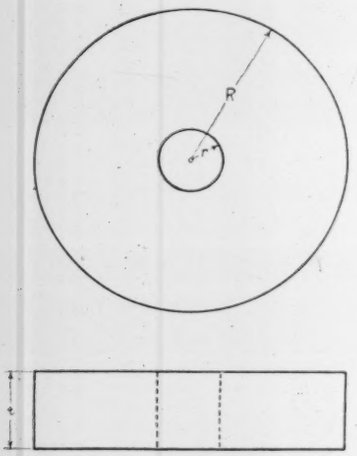


FIG. 1 TYPICAL HEAD WITH CENTRAL HOLE
(Any portion of head outside support circle not considered.)

such a hole, no matter how it may be plugged, stuffed or capped, the head is considered unrestrained aroung the hole, for the same reasons for which it is considered simply supported around the margin, on the ground that no pipe, rod, cap or other device can have more than a slight restraining effect. Any slight degree of

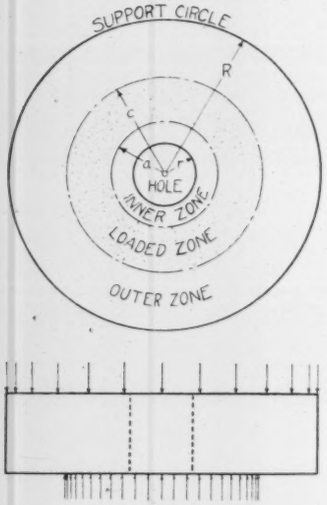


FIG. 2 DIAGRAM OF TYPICAL LOAD
(Uniformly distributed over annular zone of radii *a* and *c*.)

fixedness which may actually exist reduces slightly the direct stresses, and reduces still more slightly the deflections. See Fig. 1.

d The loading is normal to the head, and may be so divided that each part is uniformly distributed over an annular zone. See Fig. 2. The three zones into which the head is divided by any such part of the loading will be called *inner zone*, *loaded zone* and *outer zone*. It is evident that this covers all cases of static fluid pressure in which the system is symmetrical with respect to all diameters. It covers also the case of a gasket load, for this may properly be regarded as uniformly distributed over a very narrow zone; in such a case, the width of the loaded zone is put equal to zero for the sake of convenience, although an absolute line contact is physically impossible. The same procedure as for a gasket load is applied, whenever there is a central hole, to a load concentrated around the edge of the hole, such as the force applied by an insert or plug. In any case where a load is treated as if concentrated on a circle, the loaded zone is considered not to exist. For the typical load, which is uniformly distributed over an annular zone, the total shearing force on any normal cylindrical section concentric with the zones (hereafter called circumferential section), having radius x, may be represented by $S = m + nx^2$, where m and n are constants pertaining to the zone cut by the section.

For the sake of convenience, the head will be regarded as horizontal. Although the loading may act partly upward and partly downward, the analysis contemplates only one part at a time, the joint effect of several loads being the aggregate of the several effects independently determined; it is therefore significant to distinguish between the opposite faces of the head as *tension face* and *compression face*, these terms having the same meaning as when applied to a simple beam.

Broadly considered, all loading is applied as normal external pressure, and causes an internal compressive force normal to the faces, throughout the loaded zone; the intensity of this force is equal to the intensity of applied pressure at the compression face, and decreases uniformly to zero at the tension face. If a load W be distributed over an annular zone of area $\pi(c^2 - a^2)$, the intensity of normal compressive force at the compression face is

$$q'_n = -\frac{W}{\pi(c^2 - a^2)}$$

the negative sign indicating compression. There are exceptions to this rule of surface application (for example, the dead weight of the head), but they are unimportant because any errors due to disregarding them are very minute in any actual case; if it be desired to take into account these exceptions, those terms in the resulting formulae which depend on the value of q'_n may simply be dropped.

NOTATION

The following notation is used throughout the paper:

R = radius of support circle. Positive. Unit = Distance
c = outer radius of loaded zone. Positive. Unit = Distance
a = inner radius of loaded zone. Positive. Unit = Distance
r = radius of central hole, if any. Positive. Unit = Distance
t = thickness of head. Positive. Unit = Distance
x = variable distance from center. Positive. Unit = Distance
y = variable deflection of neutral surface due to flexure alone. Positive. Unit = Distance
Y = variable deflection of neutral surface due to detrusion alone. Positive. Unit = Distance
z = variable vertical ordinate of a point in the head, measured from neutral surface. Positive if measured in some direction as load, negative if opposite. Unit = Distance
W = total load on loaded zone. Positive. Unit = Force
E = modulus of elasticity (Young's). Positive. Unit = $\frac{\text{Force}}{\text{Dist. squared}}$
λ = Poisson's Ratio. Positive. Pure Number
S = variable total vertical shearing force on a circumferential section. Positive. Unit = Force
s = variable intensity of vertical or horizontal shearing force in a vertical radial plane, at any point in the head. Positive. Unit = $\frac{\text{Force}}{\text{Dist. squared}}$
s_m = Value of s at any point in neutral surface.

The symbols for the intensities of internal stress and of internal force, other than shear, are given in the following table:

	TENSION FACE			COMPRESSION FACE		
	Radial	Tangent	Normal	Radial	Tangent	Normal
Direct Stress	p_r	p_t	p_n	p'_r	p'_t	p'_n
Direct Force	q_r	q_t	q_n	q'_r	q'_t	q'_n

The quantities represented in this table are positive if tensile, negative if compressive. Their common unit is Force ÷ Distance squared. Direct stress intensity is defined as the rate of direct strain multiplied by E.

Although the deflections, which occur in the same direction as the load causing them, are considered positive, heed must be given

to the fact that separate loads, acting in opposite directions, cause opposite deflections. Both y and Y are considered zero at the support circle.

The neutral surface is everywhere midway between the two faces, but its distance from either face is slightly affected by diminution of the thickness t due to surface application of loading However, this effect is so exceedingly small, that it will be considered in this analysis to be quite negligible. Therefore the deflection of either face, for any value of x, will be regarded as identical with the deflection of the neutral surface for that value of x. The fact that detrusive strains cause curvature of the normal elements does not invalidate this proposition. No proofs are given for the statements contained in this paragraph, for they are based on general theory and are not peculiar to the problem in hand.

EQUATIONS FOR FLEXURE AND DIRECT STRESS

Equations [1] through [15] provide means for determining flexure strains, direct internal forces and direct stresses at all points. Formulas for the constants of the integration are required and these are given for various physical conditions in Equations [16] through [45]. The derivation of these equations is given in the complete paper which may be procured from The American Society of Mechanical Engineers.

The shear deflections may be obtained from Equations [46] through [49].

Inner zone:

$$y = \frac{3(1-\lambda^2)W}{4\pi E \cdot t^3}\left[A_1 \log_e x + B_1 - C_1 x^2\right] \quad [1]$$

$$q_i = -q_i' = \frac{3W}{8\pi t^2}\left[-\frac{A_1}{x^2}(1-\lambda) + 2C_1(1+\lambda)\right] \quad [2]$$

$$q_e = -q_e' = \frac{3W}{8\pi t^2}\left[+\frac{A_1}{x^2}(1-\lambda) + 2C_1(1+\lambda)\right] \quad [3]$$

$$p_i = -p_i' = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[-\frac{A_1}{x^2} + 2C_1\right] \quad [4]$$

$$p_e = -p_e' = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[+\frac{A_1}{x^2} + 2C_1\right] \quad [5]$$

Loaded zone:

$$y = \frac{3(1-\lambda^2)W}{4\pi E \cdot t^3}\left[A_2 \log_e x + B_2 - \frac{2a^2}{c^2-a^2}x^2 \log_e x - C_2 x^2 + \frac{x^4}{4(c^2-a^2)}\right] + \frac{\lambda \cdot W \cdot x^2}{2\pi E t(c^2-a^2)} \quad [6]$$

$$q_i = -q_i' = \frac{3W}{8\pi t^2}\left[-\frac{A_2}{x^2}(1-\lambda) + \frac{4a^2}{c^2-a^2}\log_e x(1+\lambda) + \frac{2a^2}{c^2-a^2}(1+3\lambda) + 2C_2(1+\lambda) - \frac{x^2}{c^2-a^2}(1+3\lambda)\right] \quad [7]$$

$$q_e = -q_e' = \frac{3W}{8\pi t^2}\left[+\frac{A_2}{x^2}(1-\lambda) + \frac{4a^2}{c^2-a^2}\log_e x(1+\lambda) + \frac{2a^2}{c^2-a^2}(3+\lambda) + 2C_2(1+\lambda) - \frac{x^2}{c^2-a^2}(3+\lambda)\right] \quad [8]$$

$$p_i = -p_i' + \frac{\lambda W}{\pi(c^2-a^2)} = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[-\frac{A_2}{x^2} + \frac{4a^2}{c^2-a^2}\log_e x + \frac{2x^2}{c^2-a^2} + 2C_2 - \frac{x^2}{c^2-a^2}\right] \quad [9]$$

$$p_e = -p_e' + \frac{\lambda W}{\pi(c^2-a^2)} = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[+\frac{A_2}{x^2} + \frac{4a^2}{c^2-a^2}\log_e x + \frac{6x^2}{c^2-a^2} + 2C_2 - \frac{3x^2}{c^2-a^2}\right] \quad [10]$$

Outer zone:

$$y = \frac{3(1-\lambda^2)W}{4\pi E \cdot t^3}\left[A_3 \log_e x + B_3 + 2x^2 \log_e x - C_3 x^2\right] \quad [11]$$

$$q_i = -q_i' = \frac{3W}{8\pi t^2}\left[-\frac{A_3}{x^2}(1-\lambda) - 4\log_e x(1+\lambda) - 2(1+3\lambda) + 2C_3(1+\lambda)\right] \quad [12]$$

$$q_e = -q_e' = \frac{3W}{8\pi t^2}\left[+\frac{A_3}{x^2}(1-\lambda) - 4\log_e x(1+\lambda) - 2(3+\lambda) + 2C_3(1+\lambda)\right] \quad [13]$$

$$p_i = -p_i' = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[-\frac{A_3}{x^2} - 4\log_e x - 2 + 2C_3\right] \quad [14]$$

$$p_e = -p_e' = \frac{3(1-\lambda^2)W}{8\pi t^3}\left[+\frac{A_3}{x^2} - 4\log_e x - 6 + 2C_3\right] \quad [15]$$

Solid head:

Inner zone:

$$A_1 = 0 \quad [16]$$

$$B_1 = \frac{3+\lambda}{1+\lambda}R^2 - (c^2+a^2)\left(\log_e R + \frac{3}{4} + \frac{1}{1+\lambda}\right) + \frac{1}{c^2-a^2}(c^4\log_e c - a^4\log_e a) - \frac{2\cdot t^2}{3(1-\lambda^2)} \quad [17]$$

$$C_1 = 2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2}{c^2-a^2}(c^2\cdot\log_e c - a^2\log_e a) + \frac{2}{1+\lambda} \quad [18]$$

Loaded zone:

$$A_2 = -\frac{a^4}{c^2-a^2} \quad [19]$$

$$B_2 = \frac{3+\lambda}{1+\lambda}R^2 - (c^2+a^2)\left(\log_e R - \frac{1}{2} + \frac{1}{1+\lambda}\right) + \frac{c^4}{c^2-a^2}\left(\log_e c - \frac{5}{4}\right) - \frac{2\lambda\cdot t^2 c^2}{3(1-\lambda^2)(c^2-a^2)} \quad [20]$$

$$C_2 = 2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{c^2}{c^2-a^2}(2\log_e c + 1) + \frac{3+\lambda}{1+\lambda} \quad [21]$$

Outer zone:

$$A_3 = c^2 + a^2 \quad [22]$$

$$B_3 = \frac{3+\lambda}{1+\lambda}R^2 - (c^2+a^2)(\log_e R - \frac{1}{2} + \frac{1}{1+\lambda} \quad [23]$$

$$C_3 = 2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} + \frac{3+\lambda}{1+\lambda} \quad [24]$$

Head with central hole of radius r:

Inner zone:

$$A_1 = -\frac{2r^2}{1-\frac{r^2}{R^2}}\cdot\frac{1+\lambda}{1-\lambda}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2}{c^2-a^2}\left(c^2\log_e c - a^2\log_e a\right) + \frac{2}{1+\lambda}\right] \quad [25]$$

$$B_1 = (C_1+1)R^2 - (A_1+2R^2)\log_e R - (c^2+a^2)\left(\log_e R + \frac{5}{4}\right) + \frac{1}{c^2-a^2}\left[c^4\log_e c - a^4\log_e a + 2R^2(c^2\log_e c - a^2\log_e a)\right] - \frac{2\lambda\cdot t^2}{3(1-\lambda^2)} \quad [26]$$

$$C_1 = \frac{1}{1-\frac{r^2}{R^2}}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2}{c^2-a^2}(c^2\cdot\log_e c - a^2\cdot\log_e a) + \frac{2}{1+\lambda}\right] \quad [27]$$

Loaded zone:

$$A_2 = -\frac{a^4}{c^2-a^2} - \frac{2r^2}{1-\frac{r^2}{R^2}}\cdot\frac{1+\lambda}{1-\lambda}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2}{c^2-a^2}(c^2\log_e c - a^2\log_e a) + \frac{2}{1+\lambda}\right] \quad [28]$$

$$B_2 = C_2\cdot R^2 - (A_2+2R^2)\log_e R + \frac{c^2}{c^2-a^2}\left[R^2 - c^2\left(\log_e R + \frac{5}{4}\right) + \log_e c(2R^2+c^2)\right] - \frac{2\lambda\cdot t^2 c^2}{3(1-\lambda^2)(c^2-a^2)} \quad [29]$$

$$C_2 = \frac{1}{1-\frac{r^2}{R^2}}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{c^2}{c^2-a^2}(2\log_e c + 1) + \frac{a^2r^2}{(c^2-a^2)R^2}(2\log_e a + 1) + \frac{3+\lambda}{1+\lambda}\right] \quad [30]$$

Outer zone:

$$A_3 = c^2 + a^2 - \frac{2r^2}{1-\frac{r^2}{R^2}}\cdot\frac{1+\lambda}{1-\lambda}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2}{c^2-a^2}(c^2\cdot\log_e c - a^2\cdot\log_e a) + \frac{2}{1+\lambda}\right] \quad [31]$$

$$B_3 = C_3\cdot R^2 - (A_3+2R^2)\log_e R \quad [32]$$

$$C_3 = \frac{1}{1-\frac{r^2}{R^2}}\left[2\log_e R - \frac{1-\lambda}{1+\lambda}\cdot\frac{c^2+a^2}{2R^2} - \frac{2r^2}{(c^2-a^2)R^2}(c^2\cdot\log_e c - a^2\log_e a) + \frac{2}{1+\lambda}\right] + 1 \quad [33]$$

Solid head, load concentrated on circle of radius c.

Inner zone:

$$A_1 = 0 \quad [34]$$

$$B_1 = \frac{3+\lambda}{1+\lambda}\left(R^2 - c^2\right) - 2c^2\log_e\frac{R}{c} - \frac{2\lambda t^2}{3(1-\lambda^2} \quad [35]$$

$$C_1 = 2\log_e\frac{R}{c} + \frac{1-\lambda}{1+\lambda}\left(1 - \frac{c^2}{R^2}\right) \quad [36]$$

Outer zone:

$$A_3 = 2c^2 \quad [37]$$

$$B_3 = \frac{3+\lambda}{1+\lambda}R^2 - 2c^2\left(\log_e R - \frac{1}{2} + \frac{1}{1+\lambda}\right) \quad [38]$$

$$C_3 = 2\log_e R + 2 + \frac{1-\lambda}{1+\lambda}\left(1 - \frac{c^2}{R^2}\right) \quad [39]$$

Head with hole, load concentrated on circle of radius c:

Inner zone:

$$A_1 = -\frac{2r^2}{1-\frac{r^2}{R^2}}\left[2\frac{1+\lambda}{1-\lambda}\log_e\frac{R}{c} + 1 - \frac{c^2}{R^2}\right] \quad [40]$$

$$B_1 = C_1\cdot R^2 - A_1\log_e R - 2R^2 + c^2\log_e\frac{R}{c} + 2(R^2-c^2) - \frac{2\lambda\cdot t^2}{3(1-\lambda^2)} \quad [41]$$

$$C_1 = \frac{1}{1-\frac{r^2}{R^2}}\left[2\log_e\frac{R}{c} + \frac{1-\lambda}{1+\lambda}\left(1 - \frac{c^2}{R^2}\right)\right] \quad [42]$$

Outer zone:

$$A_3 = 2c^2 - \frac{2r^2}{1-\frac{r^2}{R^2}}\left[2\frac{1+\lambda}{1-\lambda}\log_e\frac{R}{c} + 1 - \frac{c^2}{R^2}\right] \quad [43]$$

$$B_3 = C_3\cdot R^2 - (A_3+2R^2)\log_e R \quad [44]$$

$$C_3 = \frac{1}{1-\frac{r^2}{R^2}}\left[2\log_e R + 2 + \frac{1-\lambda}{1+\lambda}\left(1 - \frac{c^2}{R^2}\right) - \frac{2r^2}{R^2}(\log_e c + 1)\right] \quad [45]$$

Inner zone $Y = \frac{3(1+\lambda)W}{2\pi Et}\left[\log_e R - \frac{1}{c^2-a^2}(c^2\log_e c - a^2\log_e a) + \frac{1}{2}\right]$ [46]

Loaded zone $Y = \frac{3(1+\lambda)W}{2\pi Et}\left[\log_e\frac{R}{x} - \frac{1}{c^2-a^2}\left(c^2\log_e\frac{c}{x} - \frac{c^2-x^2}{2}\right)\right]$ [47]

Outer zone $Y = \frac{3(1+\lambda)W}{2\pi Et}\log_e\frac{R}{x}$ [48]

Inasmuch as the distance between the neutral surface and either face remains constant for all values of x and for all conditions of loading (except for the exceedingly small reduction in this distance due to surface application of load, which has nothing to do with detrusion), the values of Y given by these equations apply to the shear deflections of both faces as well as of the neutral surface.

With respect to shear, it is not necessary to distinguish between a solid head and one having a central hole.

To handle the case of a load concentrated on a circle of radius c, let a approach c as a limit in Equation [46]:

Load concentrated on a circle of radius c:

Inner zone $$Y = \frac{3(1+\lambda)W}{2\pi Et} \log_e \frac{R}{c} \quad \ldots\ldots\ldots [49]$$

Outer zone Use Eq. [48]

The treatment of shearing stresses and deflections is thus completed. The formulas are so simple, that it is not thought necessary to discuss their application to special cases.

Evidently the total or resultant deflection of the head at any point, is equal to the sum of the resultant flexure deflection y and the resultant shearing deflection Y at that point.

Illustration

Two fairly typical cases have been analyzed for the purpose of illustrating the application of this article, and the results are shown diagrammatically in Figs. 3 and 4. The two cases are alike, except that the first is that of a solid head, whereas the second is that of a head having a central hole.

Each head is of steel 13 in. thick, and is simply supported on a circle 54 in. in diameter. The gasket is of appreciable width, but for convenience is considered to form a line contact along a circumference 42 in. in diameter. The total gasket load is 491,300 lb. Gas pressure is applied over the entire area of a circle 40 in. in diameter, this being the inside diameter of the gasket; the intensity of this pressure is 2000 lb. per sq. in. In the case of the head with the hole, the gas load acting on the stopper of the hole is transmitted to the head as a shear at the edge of the hole, which is 6 in. in diameter. The steel has a modulus of elasticity of 30,000,000 lb. per sq. in., and Poisson's ratio is taken as $^1/_3$.

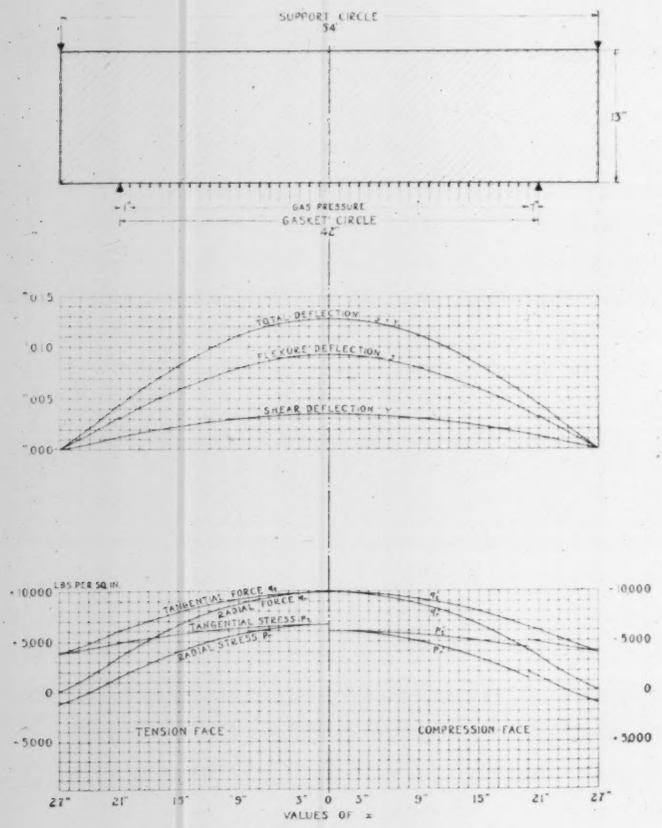


Fig. 3 Analysis of Solid Circular Head

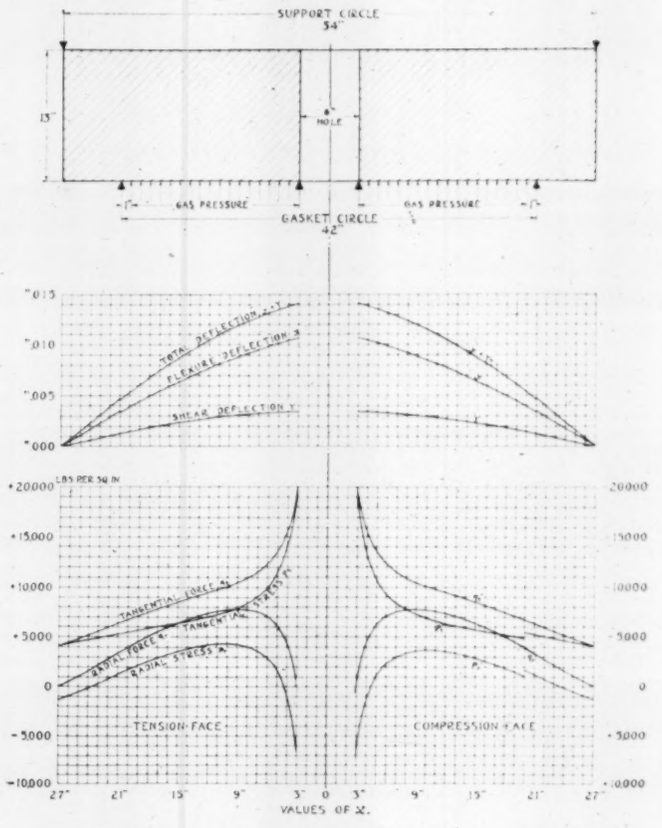


Fig. 4 Analysis of Circular Head Having a Central Hole

The following are the values of the other given constants, which are different for different parts of the analyses:

$R = 27$ in.	$E = 30{,}000{,}000$ lb. per sq. in.
$t = 13$ in.	$\lambda = {}^1/_3$

Solid Head	Head with Hole
Gas load—2 zones, loaded and outer	Main gas load—2 zones loaded and outer
$W = 2{,}513{,}300$ lb.	$W = 2{,}456{,}700$ lb.
$c = 20$ in.	$c = 20$ in.
$a = r = 0$	$a = r = 3$ in.
	Gas load on stopper outer zone only
	$W = 56{,}600$ lb.
	$c = a = r = 3$ in.
Gasket load—2 zones, inner and outer	Gasket load—2 zones, inner and outer
$W = 491{,}300$ lb.	$W = 491{,}300$ lb.
$c = a = 21$ in.	$c = a = 21$ in.
$r = 0$	$r = 3$ in.

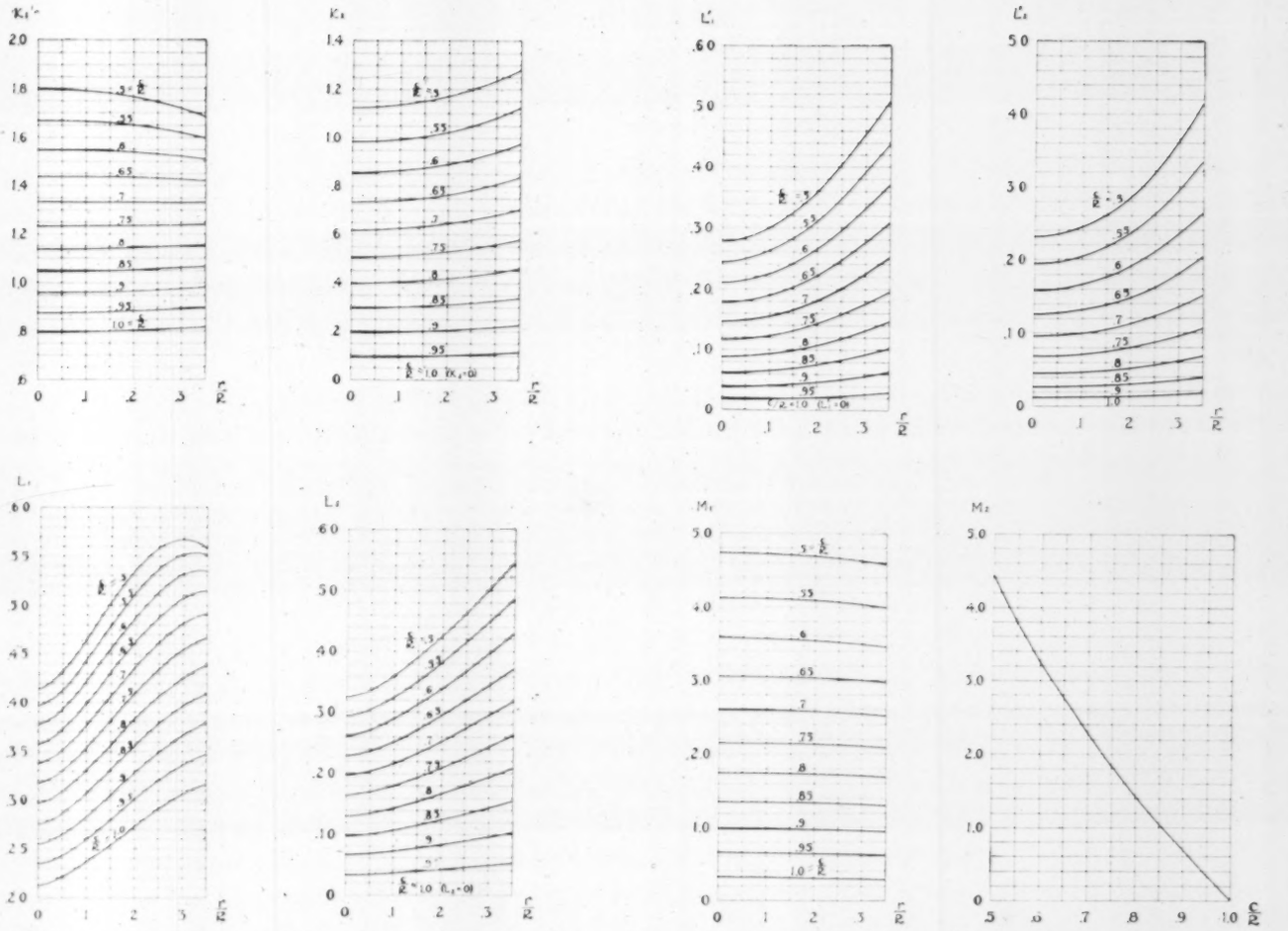
The deflections, forces and stresses are determined separately for the several loads in each case, and the results are added to find the resultant effects. These results are plotted in Figs. 3 and 4. The break in the flexure deflection curve in each case is due to the assumed line application of gasket load, as explained in the analysis, and is numerically equal to 0.000067 in.

Charts

Figs. 5 to 12 facilitate the computation of critical stresses and deflections in cases commonly occurring, subject to the assumption of $^1/_3$ as the value of Poisson's ratio λ.[1]

Eight auxiliary quantities are introduced, *viz.* K_1, K_2, L_1, L_2, L'_1, L'_2, M_1, M_2. Each of these except M_2, is a function of r/R and c/R, r/R being zero in the case of a solid head; M_2 is a function of c/R alone. Each of the eight charts yields the value of one of these auxiliaries in any given case.

[1] For steel, $^1/_3$ is a convenient approximate value commonly employed; scarcity of experimental information in regard to lateral strains makes it useless to seek refinement in regard to the value of λ.



FIGS. 5 TO 8.—CHARTS FOR FACILITATING COMPUTATION OF CRITICAL STRESSES AND DEFLECTIONS IN COMMONLY OCCURRING CASES. POISSON'S RATIO BEING TAKEN AS 1/3

FIGS. 9 TO 12.—CHARTS FOR FACILITATING COMPUTATION OF CRITICAL STRESSES AND DEFLECTIONS IN COMMONLY OCCURRING CASES. POISSON'S RATIO BEING TAKEN AS 1/3

TABLE 1 AUXILIARY FORMULAS FOR USE WITH CHARTS, FIGS. 5 TO 12

	Symbol	Solid Head (put $r/R = 0$): Due to load W distributed over area of circle, radius c	Solid Head (put $r/R = 0$): Due to load W concentrated on circumference, radius c
Intensity of stress in tension face at center	$p_t = p_r$	$\frac{W}{t^2} \cdot K_1$	$\frac{W}{t^2} \cdot K_2$
Intensity of stress in compression face at center	$p'_t = p'_r$	$-\frac{W}{t^2}\left(K_1 - \frac{1}{\pi c^2}\right)$	$-\frac{W}{t^2} \cdot K_2$
Center deflection due to flexure	y	$\frac{W}{Et}\left(\frac{R^2 L_1}{t^2} - \frac{1}{6\pi}\right)$	$\frac{W}{Et}\left(\frac{R^2 L_2}{t^2} - \frac{1}{6\pi}\right)$
Center deflection due to shear	Y	$\frac{W M_1}{E \cdot t}$	$\frac{W M_2}{Et}$
Deflection at radius c due to flexure	y	$\frac{W R^2 L'_1}{Et^3}$	$\frac{W}{Et}\left(\frac{R^2 L_2}{t^2} - \frac{1}{12\pi}\right)$
Deflection at radius c due to shear	Y	$\frac{W M_2}{Et}$	$\frac{W M_2}{Et}$

	Symbol	Head with Central Hole of Radius r: Due to load W distributed over area of circle, radius c	Head with Central Hole of Radius r: Due to load W concentrated on circumference, radius c
Intensity of tangential stress in tension face at edge of hole	p_t	$\frac{W}{t^2} \cdot K_1$	$\frac{W}{t^2} \cdot K_2$
Intensity of tangential stress in compression face, edge of hole	p'_t	$-W\left(\frac{K_1}{t^2} - \frac{1}{3\pi c^2}\right)$	$-\frac{W}{t^2} \cdot K_2$
Deflection at edge of hole due to flexure	y	$\frac{W}{Et}\left(\frac{R^2 L_1}{t^2} - \frac{1 - r^2/c^2}{6\pi}\right)$	$\frac{W}{Et}\left(\frac{R^2 L_2}{t^2} - \frac{1}{6\pi}\right)$
Deflection at edge of hole due to shear	Y	$\frac{W M_1}{Et}$	$\frac{W \cdot M_2}{Et}$
Deflection at radius c due to flexure	y	$\frac{W R^2 L'_1}{Et^3}$	$\frac{W}{E \cdot t}\left(\frac{R^2 \cdot L'_2}{t^2} - \frac{1}{12\pi}\right)$
Deflection at radius c due to shear	Y	$\frac{W M_2}{Et}$	$\frac{W M_2}{Et}$

The simple formulas classified in Table 1 give the stresses and the deflections at the center in the case of a solid head, or the tangential stresses and the deflections at the edge of the hole in the case of a centrally bored head, due to any load W uniformly distributed over the entire area of a circle of radius c concentric with the support circle, or due to any load W concentrated along the circumference of such a circle.

The formulas giving the effects of a distributed load, in the case of a head with a central hole, include the effects of that portion of the load which acts on the area of the hole and which is transmitted to the edge of the hole by the stopper which closes the hole; the proper value of use for W is the total pressure within the circle of radius c.

The formulas by means of which the auxiliary quantities were computed, are not reproduced here, being cumbersome; they were reduced directly from formulas derived in the earlier part of this article, with λ put equal to 1/3. It is to be noted that these auxiliaries do not serve to give stresses and deflections *at all points*, as do the formulas of the analysis; they give only particular stresses and deflections of major importance.

The main practical purpose served by the charts is as follows. In the case of a steel cylinder head of uniform thickness t, simply supported around a circle of radius R, having a central hole of radius r (which is considered zero in case there is actually no such hole), sustaining a gasket load concentrated along a circumference of radius c, and sustaining also a static fluid pressure acting on the entire area enclosed by the gasket circle, *to find the maximum intensities of tensile and compressive stress, the maximum deflections due to flexure and shear, respectively, and the deflections at the gasket circle due to flexure and shear, respectively.*

DISCUSSION OF PAPER ON DEFORMATION OF CYLINDER HEADS

THE attendance at the General Session at which G. D. Fish presented his paper on stresses and deformation in flat circular cylinder heads was limited to a few particularly interested in this subject. The discussion took the form of a round-table talk in which the author answered the questions of this interested audience and explained further details of the problem presented in his paper. A résumé of the important points touched upon and bearing most directly upon the subject of the paper is given below.

W. H. Runkel[1] in opening the discussion asked what factor of safety was used in the flat cylinder heads designed for the nitrate plant. The author replied that a maximum intensity of direct stress of 10,000 lb. per sq. in. was allowed. The material was forged steel, and was expected to be a special alloy. Tests were being made at the Bureau of Standards, at the time the author severed his connection with the Bureau, to determine its strength, at high temperature, and the effect of a hole in it. Many specimens composed of carbon steel, nickel-carbon steel, chrome-vanadium steel, and molybdenum steel were being pulled at high temperatures. The ultimate strength of all the alloys was increased by elevating the temperature to 300 or 400 deg. fahr., but there was a tendency to decline beyond these values, which finally dropped off decidedly at more elevated temperatures.

Conrad C. Jacobson[2] asked if there was not a limit to the efficient thickness of the head, where a very high pressure was developed and there was a tendency toward bending between the bolt circle and the gasket circle. Would it not be a better design, he asked, to use hydraulic clamps directly through the gasket circle, rather than to depend on the bolt circle, and thus do away with this flexure?

The author answered that actual trials with screwed-in heads with the thrust directly against the gasket resulted in serious leakage.

Mr. Jacobson said that this was because no follow-up had been provided, and when the elasticity was gone there was a space between the head and the flange which decreased the initial tension on the gasket. He said that he was talking from experience, in work in which old-fashioned methods were used, but trouble was found in keeping tight joints. No matter how thick the heads were made, there was an initial pressure on the gasket with bolts.

The author said that his method was to calculate the deflation or bulging between the bolt circle and the gasket under a condition of bolt tension, without gas pressure, and also under the condition of bolt and gas pressure. If the overhang on the head beyond the gasket was properly proportioned to the other elements, there was a residual gasket pressure after the gas pressure was applied, and it was found feasible to do with a residual gasket pressure equal to about one-fifth of the total gas pressure. The elasticity of the plate made it possible to retain a residual gasket pressure after the gas pressure was applied.

Mr. Jacobson asked if it was always possible to determine the exact pressure that would be developed by the liquid pressure of the material handled.

The author answered that exact calculations were theoretically but not actually possible. The pressure in the system was maintained by means of a standard type of compressor, and the loss of head through the various members of the circulating system was quite definitely known, so that operating conditions were subject to fairly accurate control, both as to pressure in the apparatus and as to temperature.

In dealing with pressures inside any containers used for other purposes than the ones he was dealing with, he would expect that the calculated pressures would be subject to variations due to impurities of catalytic agents, and that certain mechanical and thermal conditions would affect the chemical equilibrium between the reagents and their product which could not be calculated exactly. Therefore, unless mechanical means were used for maintaining the system at a fixed pressure, a considerable percentage of variation in the pressure might be expected.

In connection with his problem there were incidental temperature differences to deal with, which meant that any construction of head or gasket which did not permit relative expansion laterally between the head and gasket seat would fail.

The bolting of the flanges seemed the most practical method for holding the gas, but even that was not very simple, because wrenches six feet long had to be used to turn up the bolts, and the ends of the wrenches had to be hit with sledges.

Mr. Jacobson, Thomas W. Milnor and the author discussed methods of fastening cylinder heads with clamps.

W. J. Drisko[1] said that he had been working on photoelectricity in connection with a number of problems of engineering interest, and the possibility of studying the distribution of stresses in a disk with a pneumatic pressure applied over the surface had occurred to him. He wondered if any information had been obtained through such means as this on the subject of the paper.

The author knew of no experimental evidence which would help Mr. Drisko. Strains, as put forth in his paper have been completely analyzed. The study of the inside of a thick plate, subject to flexure, showed that the normal elements which were straight before flexure, became curved after flexure, not due to that portion of the deflection which is called flexure but due to detrusion or shear. This was so slight that it would take a photomicrometer to detect it.

Elwyn E. Seelye[2] presented the following written discussion.

The method of analysis used by the author is based upon the elastic theory and is one of the most interesting examples of applied mathematics of which the writer is familiar. Where homogeneous material is in question, if the correct equations are written, very exact results may be looked for.

The writing and solving of these differential equations required considerable knowledge of higher mathematics.

It is interesting to examine the difference in results obtained by analyzing a cylinder head by ordinary statics as compared to the far more correct analysis based on the elastic theory.

In order to make the case as simple as possible, let us take the case of a circular plate uniformly loaded and simply supported around its perimeter, taking the moment about a diametrical section. The moment is readily obtained by determining the location of the center of gravity of the semicircle and the half perimeter, respectively. This gives us a total moment through the diametrical action of $\frac{w\gamma}{3\pi}$, which gives an average unit stress of $\frac{w}{\pi t^2}$, which if assumed to be parabolic in distribution gives a maximum stress at center of $\frac{1.5w}{\pi t^2}$ as compared with $\frac{0.83w}{\pi t^2}$ by the elastic formula.

This contrast in even greater if there is a small hole in the center of the head when the maximum stress is tangential and is three times that of a solid head, whereas the statical solution would increase the stress only directly with the material omitted.

These surprising differences are met with by engineers in floor-construction designs, particularly in the case of flat-slab construction, and affect the mechanical engineer in relation to the strength and economy of his plant-housing structures.

In the course of a paper read before the Institution of Engineers and Shipbuilders in Scotland. Mr. W. Rees Darling described a form of gear for marine propulsion. The place of the teeth on the pinion is taken by a bundle of loose wire rollers, which are free to move and adapt themselves to the form of the teeth on the gear wheel. Pinions of the new type may be moved into gear instantaneously or gradually while revolving at any speed. This is done regularly at present at a speed of 2000 revolutions per minute without shock or danger of any kind. The pinions in use so far have been fitted for the purpose of surmounting difficulties which had previously seemed insuperable, and have proved entirely successful.—*The Engineer*, Jan. 20, 1922.

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[1] New York City.

[2] Developing Engr., The Celluloid Co., 290 Ferry St., Newark, N. J. Assoc-Mem.Am.Soc.M.E.

[1] Dept. of Phyiscs, Mass. Inst. of Tech., Cambridge, Mass.

[2] Cons. Engr., 101 Park Ave., New York, N. Y.

A Discussion of Draft Tube Designs[1]

With Special Reference to Recent Forms Known as the Hydraucone Regainer and the Spreading Draft Tube

By WEBSTER K. RAMSEY,[2] BOSTON, MASS.

THE purpose of this paper is not to present the hydraulic draft tube from a highly theoretical standpoint, but rather from an angle which will be of interest to the greatest number at the present time. It will be surprising to any one who has studied the subject at all to find what a large number of operating hydraulic engineers have but a limited knowledge of either the importance of the draft tube or the action of the water in the different types.

The primary requisite for an understanding of the draft-tube effect upon the water is a knowledge of the action of the water as it issues from the runner of the turbine. In the explanation which follows, a vertical turbine is considered.

Condition of Water Discharged from Turbine Runner

The condition of the water discharged from a runner depends upon the specific speed of the runner. With specific speeds up to 50, which designates a medium-head installation, the water is discharged in such a manner as to cause it to whirl in the same direction as the rotation of the runner, up to best gate. At best gate the water flows practically radially inward. Above best gate the whirl is in the opposite direction to the rotation of the runner. Considering values of specific speed above 50, which designates low-head installations, the velocity of whirl increases in magnitude as the specific speed increases. In this case the water does not change its direction of whirl even after best gate conditions are reached. It is particularly the low-head, high-specific-speed runners having high velocities of whirl which concern the draft-tube requirements, as will be shown later.

The following discussion, in order to cover every condition of whirl, considers a runner which

1 Below best gate gives a velocity of whirl in the same direction as the rotation of the runner; decreasing in magnitude as the gate opens

2 At best gate gives practically radially inward flow with no whirl; and

3 Above best gate gives a velocity of whirl in the opposite direction to the rotation of the runner, increasing in magnitude as the gate opens.

The Draft Tube

Turning now to the draft tube, it will be found that this device is used to permit the turbine being placed high enough above tail-water level to give accessibility. In providing an air-tight tube to conduct the water from the turbine runner to the tail race, it is hoped that a good part of the head lost because of the position of the turbine will be regained by the vacuum caused by the weight of the solid column of water flowing downward to the tail race. The problem, however, is not so simple. The water drops with a certain initial axial velocity even at best gate; off best gate there is added a velocity component of whirl. Water is discharged from a runner with a very high exit velocity, especially in the case of a low-head, high-specific-speed installation. This velocity represents a certain amount of static head acting on the wheel. If this discharged water is allowed to reach the tail race without giving up most of its velocity, then just so much energy will be lost.

The purpose of the draft tube, then, is to regain the axial component of velocity and the whirl component as well. In any case the regain, which is usually provided for by supplying a tube of increasing cross-sectional area which regains static head (H_s) from velocity head (H_v) in accordance with Bernoulli's theorem, will be practically impossible unless the water can be made to flow in parallel stream lines and without cross-currents or eddies. The nature of the installation in low-head plants has added one more requirement which demands that the discharged water be turned through an angle of 90 degrees in the shortest possible distance measured in the direction of flow. This latter requirement saves the costly excavation otherwise necessary.

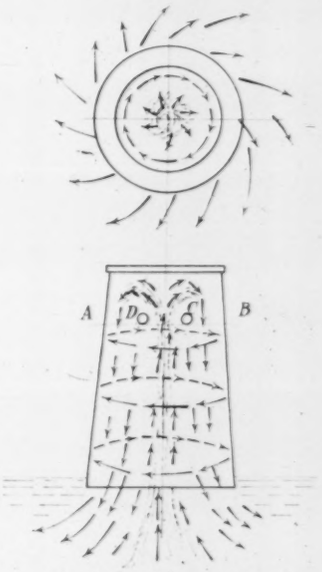

Fig. 1 Short, Straight Draft Tube

The Plain, Short Straight Draft Tube

Consider a short, straight draft tube discharging into a tail race as shown in Fig. 1. When the turbine is operating below best gate, the water is discharged down the draft tube at an angle. Starting at 0.1 gate, and measuring the angle of flow with respect to the vertical axis of the tube, it is found that the angle of whirl near the sides of the tube is greatest at the lower gates, gradually decreasing until vertical (zero angle) at best gate. If the turbine mechanism is so arranged as to allow the gates to be opened much beyond best gate, the angle will be on the other side of the vertical, showing that the angle of whirl has been reversed, and instead of the water whirling in the same direction as the runner, it will whirl down in the opposite direction.

Now, when the water is whirling down a draft tube with great centrifugal force, the action causes water to be drawn up in the central part of the tube. See Fig. 1. This column ascends to a point directly beneath the runner, where it turns over and down and is discharged down the tube again with the water which is being discharged from the turbine.

The presence of this column of upward-flowing water is very undesirable in that it increases friction losses as well as reduces the static head or vacuum which would be formed and maintained directly below the runner.

It is important to note at this point that when the runner is discharging water at best gate, the water is flowing down in practically straight stream lines. Under this condition, there is no centrifugal action to cause the water to be drawn up from the tail race. There is, however, a loss due to sudden expansion at the discharge end of the tube.

It is also to be noted that in a tube of this type there is practically

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[1] The present paper includes a part of a thesis submitted by Messrs. F. M. Rowell, R. A. Snow, M. H. Winchester and the author to the Massachusetts Institute of Technology in May, 1921, for the degree of Bachelor of Science, Parts I and II of which respectively dealt with an efficiency test of an Allis-Chalmers vertical hydraulic turbine, and a test of a White hydraucone draft tube. The apparent action of the water in the White regainer as tested led the author to investigate the action of the water in the light of the known conditions existing in other tubes.

It is to be noted that the thesis as submitted, which was practically the same as this paper with the exception of the more detailed description of the Moody spreading tube, was given to the Institute previous to the presentation of the paper on the White hydraucone regainer at the A.S.M.E. Spring Meeting in Chicago. The essence of the discussion following the presentation of the White paper as found in the July, 1921, issue of Mechanical Engineering was contained in the above thesis as submitted in the middle of May, 1921.

The author wishes to acknowledge suggestions from Mr. W. M. White, received in an interview, regarding the construction of a pitot tube and method of testing the hydraucone regainer; and from Mr. L. F. Moody concerning the Moody spreading draft tube.

[2] Student, 1922, Mass. Inst. Tech.

Presented at the Student Session of the Annual Meeting of The American Society of Mechanical Engineers, New York, December 8, 1921. Slightly abridged. All papers are subject to revision.

no provision made for straightening out the water flow and thereby utilizing even the short length of tube which has an increasing cross-sectional area. Further, no provision is made for turning the water through 90 degrees, which is one of the chief requirements of a low-head installation.

Flaring Draft Tubes

Until the advent of the radial draft tubes the usual method of discharging water from a low-head turbine was to provide a flaring tube having a short 90-deg. bend as shown in Fig. 2.

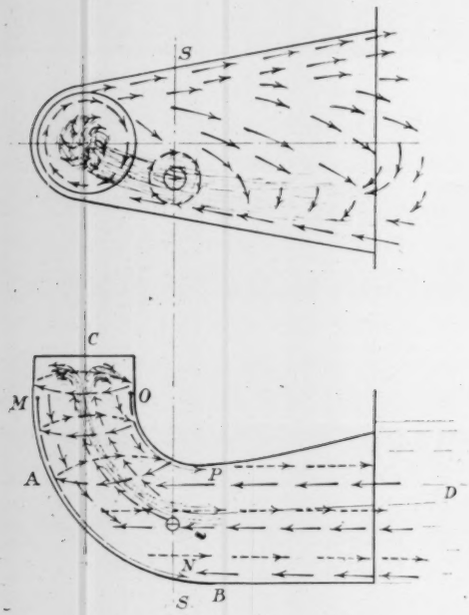

Fig. 2 Flaring Draft Tube with Short Body

If the turbine was operated always at best gate, it is easy to see that the direction of the water would be changed by friction along *AB*. Assuming that a full tube section of water started from *C*

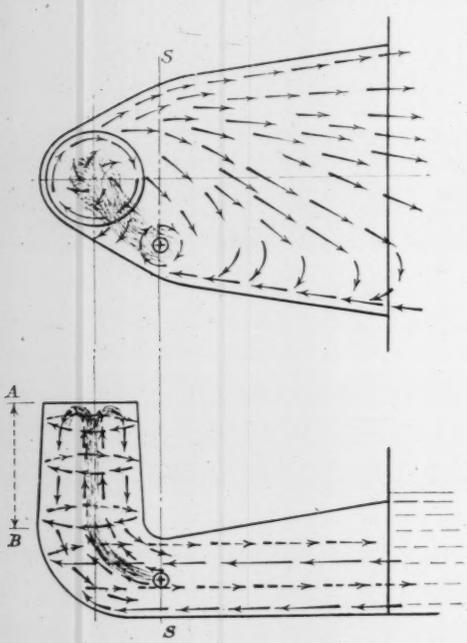

Fig. 3 Flaring Draft Tube with Long Body

to *D*, it is to be noted that this water would pass points *M* and *O* with the same velocity. Assuming the runner discharges water at an equal rate over the entire area at *C*, it can be seen that as the water turns the 90-deg. bend the inner particles flowing along *OP* will not have the same velocity as those flowing along *MN*. Hence an eddy loss—a loss caused by cross-currents set up by the sliding of one layer of water over another—is present in this form of tube, even when operating at best gate. It has been further found that when straight stream-line conditions are obtained, the high-velocity water will flow along the bottom half of the horizontal portion of the tube and discharge below the point *D*. In not a few cases it has been found that when the upper portion of the flare was a little too high, the water actually flowed back into the tube above the line *D*.

Considering actual operation, a turbine is almost always enough off best gate to cause considerable whirling of the water. This whirling body of water possesses properties not unlike those of the rotating wheel of a gyroscope, and like a gyroscope it tends to keep in a plane perpendicular to its initial axis. Hence it will be seen that the water will not continue to rotate in a plane perpendicular to the central axis of the draft tube upon reaching the bend in the tube. This theory is substantiated by noting that the drawing action caused by the commotion of the water at the bend, as shown in Fig. 2, renders a part of the discharge area ineffective. In most cases the water actually flows back into the draft tube and is drawn from the points of most violent eddying (marked "+") up into the vertical portion as shown. In not a few cases the combined effect of the actions stated causes a complete loss of the total draft head available.

The construction of this type is not a factor in its favor. The best of these designs are made in concrete. When made of steel,

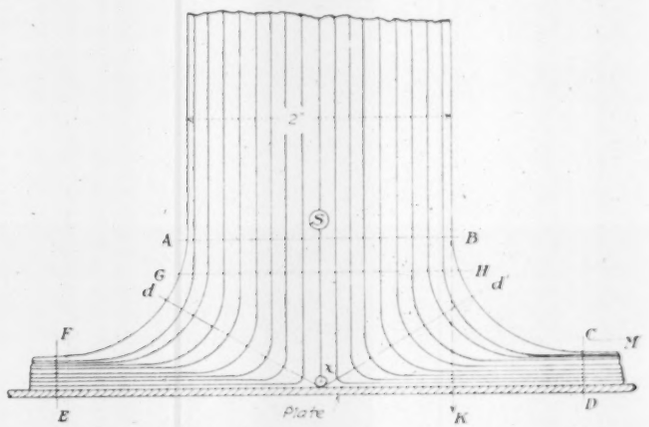

Fig. 4 Hydraucone and Hydraucone Action

the tube should bend smoothly at the elbow and not be made up of flat sections of steel plate.

Fig. 3 shows a draft tube similar to that of Fig. 2 with the exception of the longer body from *A* to *B*. This longer body has the effect of straightening the flow lines of the water, thus rendering it in a better condition for regaining through the diverging tube. It is evident that this design requires a greater distance from the horizontal center line of the turbine runner to the bottom of the tail race. The beneficial effect of the added length *AB* is actually very small.

The Hydraucone

Mr. W. M. White, manager and chief engineer of the hydraulic department of the Allis-Chalmers Manufacturing Company at Milwaukee, Wis., was the first to patent a means whereby static head could be regained from velocity head, and the direction of water be changed at the same time, in the shortest possible distance measured in the direction of the flow of water. These changes are brought about by what is called by the inventor the "hydraucone action" of the water, together with the regaining qualities of the design which act in accordance with Bernoulli's theorem.

The "hydraucone" is that portion of water bounded by the surfaces *AB* and *CD-EF*, Fig. 4, and its action, in the case of the straight jet normal to the plate, is to turn the water through ninety degrees without losing any velocity, and at the same time preserving parallel stream lines. The velocity head, moving vertically downward, is converted into static head, and this head used to reconvert

the static head into velocity head again, but in a horizontal direction with a very high efficiency.

THE WHITE HYDRAUCONE DRAFT TUBE

Realizing the importance of the hydraucone action of the water under the above conditions, Mr. White conceived the idea of utilizing the action to changing the direction of the water flowing from low-head turbines where expense of excavating for a long, straight draft tube would be prohibitive. The development of the White hydraucone draft tube is herein explained.

Referring to Fig. 4, a jet of water is shown impinging on a flat plate. The flat plate, which is the base of the hydraucone chamber, is made preferably circular and placed concentric with respect to the discharging jet.

Now, if the conoidal surface of the hydraucone, as *ABCF*, were enclosed in a closely fitting chamber, surface friction would result. Hence, a conoidal chamber is so constructed as to be slightly larger than the volume of a free hydraucone. At this point we have an enclosed hydraucone possessing all the characteristics of a free hydraucone. A step further is taken. In order to regain pressure from velocity it is necessary to provide a tube of increasing cross-sectional area. Therefore the conoidal chamber is not only made large enough for a free hydraucone with provision for friction, but also is slightly flared at the lower end, thus combining in one chamber the direction-changing action of the hydraucone with the pressure-regaining action of the section of increasing cross-sectional area.

The complete development of the design is shown in Fig. 5, a study of which will show how the pressure is regained in the following four distinct steps:

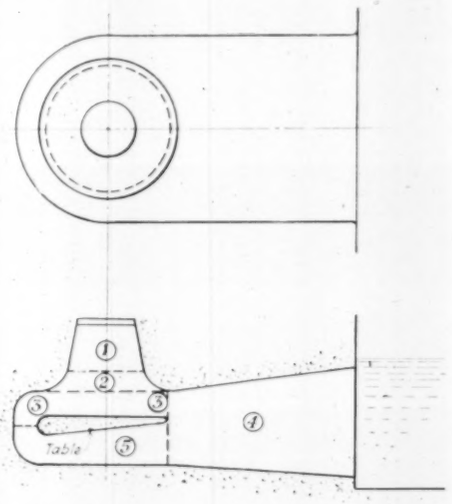

FIG. 5 WHITE HYDRAUCONE REGAINER AS PATENTED

1 First regain due to the diverging draft tube
2 Second regain due to the diverging hydraucone chamber
3 Third regain due to increasing area as water flows radially outward along the plate
4 Fourth regain due to the diverging draft tube which leads to the tail race
5 Collecting-chamber under the hydraucone baseplate. It serves as a place for collecting all the water coming off the plate and directing this water out through the section (4) into the tail race.

TEST ON THE WHITE HYDRAUCONE DRAFT TUBE

The discussion of the hydraucone up to this point has considered that the water issuing from the runner was moving in a radially inward direction and falling thence vertically down the draft tube. In actual practice, as before stated, this is seldom the condition. It is necessary, therefore, that we make a test to ascertain just what happens in a hydraucone-equipped draft tube when the water does not drop vertically downward like a jet, but comes whirling down at a sharp angle.

The draft tube on which this test was run was a part of an Allis-Chalmers 1875-kva. hydroelectric unit at Greggs Falls, N. H. The draft tube is equipped with a White hydraucone tube as shown in Fig. 6.

Ten tests were made in the following manner: The turbine was brought up to speed (257 r.p.m.), and by means of the load-limiting device on the back of the Allis-Chalmers governor, the gate was allowed to open to 0.1 gate. A special long pitot tube was then pushed into the draft tube until the tip was at the extreme opposite zone of the section. Both static-head and velocity-head hoses were

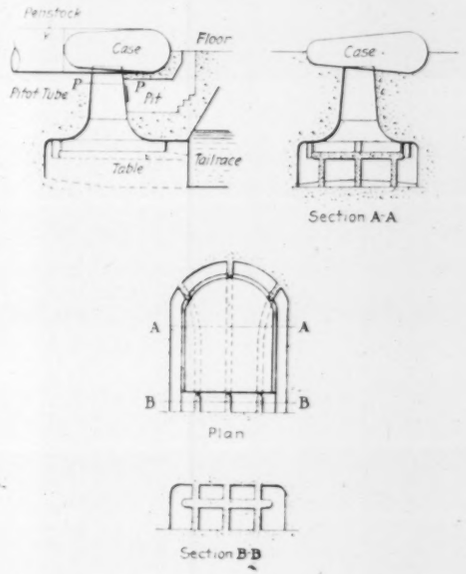

FIG. 6 WHITE HYDRAUCONE REGAINER AS INSTALLED AT GREGGS FALLS, N. H.

connected to the U-tube of mercury. Knowing that the water was whirling down the draft tube at an angle, the exact position of the normal element of water was ascertained by turning the nozzle of the tube until the maximum velocity-head reading was obtained. At this position the velocity head and the angle of the nozzle were read. Holding the tube firmly, the velocity hose was disconnected and the static head read for that position. The tip was then drawn back into the next zone, of which there were ten, and readings taken in a similar manner. Having traversed the draft tube across the diameter at 0.1 gate, the turbine was brought up to 0.2 gate (speed constant throughout) and readings obtained in the same way as at 0.1 gate. In like manner readings were recorded for each tenth gate up to maximum gate opening (1.0).

An inspection of the curves of Fig. 7 shows that negative velocity-head (H_v) and high static-head (H_s) readings were obtained in the central area of the draft tube at the lower gates, gradually diminishing in magnitude until at 0.9 and 1.0 gates all the velocity-head readings were positive and all the static-head readings were of not unusual magnitude.

The results show further that the angle the nozzle made with the vertical axis of the draft tube was greatest at the lower gates. It was also noticed that at the gates showing negative H_v readings the angle was greatest at the side of the draft tube and gradually decreased until, at the point of negative readings in the central area, the nozzle was vertical.

From the results of the readings taken by the use of a pitot tube traversed across the draft tube as previously explained, the following are noted:

a The velocity and angle of whirl of the water in the draft tube are greatest at low gates, decreasing as the gate is opened
b The negative velocities occur at the low gates when the angle of whirl of the water is greatest
c When negative velocity-head readings are obtained, the pitot-tube nozzle was vertical and in the central area of the draft tube
d The vacuum is greatest at lowest gate, decreasing as the gate is opened.

Recalling the conditions which produce the negative velocity-

head readings in the case of the short, straight draft tube, similar readings on this test appear to indicate that the column of upward-moving water is still present in this type of draft tube.

The construction of the hydraucone-chamber baseplate seems to indicate that it would be impossible for water to be sucked out of the tail race across the top of the plate and thence up the draft tube.

A more logical explanation as to the source of the upward-moving column of water is that water is picked up off the inner surface of the discharged water which is whirling down the draft tube as shown in Fig. 8. It is quite conceivable that the water is whirling around the circumference of the inner surface of the draft tube, leaving plenty of space in which the column of water could rise. At any rate there exists this upward-moving column of water in this design when the turbine is operating at the lower gates.

It is now necessary to consider whether the hydraucone action of the water is still present. In view of the foregoing paragraphs, the writer is inclined to doubt it when the turbine is operating off best gate and the water is whirling down the tube. The water now impinging on the plate is not a straight jet and therefore the action of a straight jet does not hold. With a straight jet, the force which builds up the static head at x, Fig. 4, is the inertia of the water falling vertically downward in a straight line all around that point. The force which prevents particle B, for instance, from continuing in a straight line vertically downward to K is the force which reacts at x and helps maintain the high static head at x.

Now the whirling water has the opposite tendency to the above, namely, a tendency to fly off at a tangent, out through the annular passage through area CD-EF, Fig. 4; or space (3), Fig. 5, and thus create a tendency to produce rather a vacuum at x than a pressure, or at any other point within the draft tube. From this it is evident that the hydraucone is probably not formed at any but the best gate.

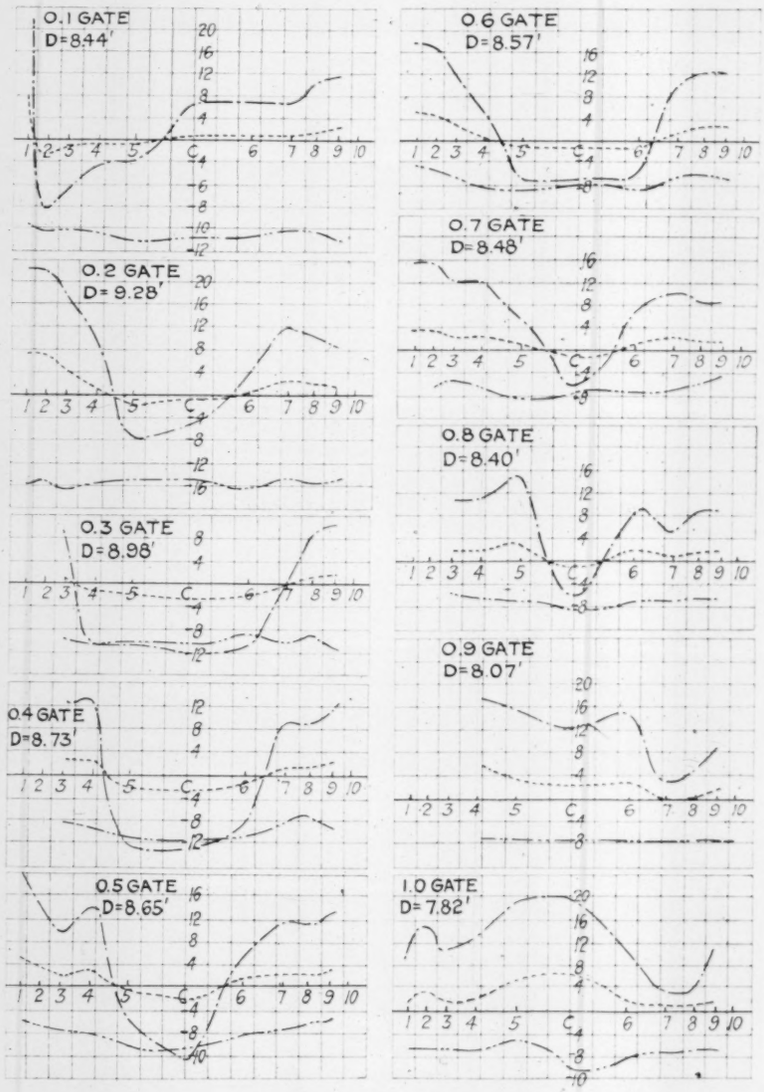

FIG. 7 VARIATION OF STATIC HEAD AND VELOCITY HEAD AS MEASURED ACROSS DRAFT-TUBE DIAMETER FOR DIFFERENT GATE OPENINGS

- - - - - - - - Velocity of static head in feet of water
—·—·—·— Static head in feet of water
—··—··—·· Velocity (ft. per sec.) as calculated from velocity-head curve
D = distance from center line of pitot tube to tail-water level.

Notwithstanding the foregoing reasoning which seems to indicate that it would be impossible to maintain a hydraucone under whirling conditions of water, the makers state that they have made exhaustive investigations regarding this phase of the subject and have found that the hydraucone action is present under *any* condition of whirl, but that the pressure at the center of the plate may decrease to some extent, such decrease being dependent upon the velocity of whirl.

If we assume that the hydraucone action is not present at any but the best gate, it is necessary to explain just what are the advantages of this design. As far as the hydraucone is concerned, the writer is inclined to believe that there is very little advantage. There is, however, a gain which more than compensates for the loss of hydraucone effect and which is explained as follows:

In order to regain static head from velocity head efficiently, and regain the energy component of whirl, the filaments of water must be made to straighten out and flow in parallel stream lines. The results of the hydraucone draft-tube test show that the lower the gate opening the worse the eddying and the greater the angle of whirl; hence no material effect from either the hydraucone action or the increasing area can be expected from sections (1) and (2), Fig. 5. Yet it will be noted that at 0.1 gate and 0.2 gate the vacuum was very great. This is explained by recalling that water, like any mass, flies off at a tangent as soon as the restraining force causing it to rotate in a circle is released. Thus, when the whirling water reaches the annular opening (3) it rushes out through the passage with great velocity. The water is then flowing in straight stream lines and is in the proper condition for maximum regain of pressure head by means of the increasing area as the water moves radially outward along the plate, and finally through the diverging tube (4) into the tail race.

The water passing out through the annular space (3) has considerable energy due to the velocity with which it is thrown out. The shape of the annular passage is of increasing cross-sectional area not unlike that of a water ejector in action, and it is because of the suction caused by this ejector action that such high vacuum readings were obtained. That the foregoing action takes place is substantiated by noting that as the gate is opened the speed and angle of the water discharging down the draft tube decrease, as also does the vacuum, until at best gate (0.9) the vacuum is normal and the centrifugal action is replaced by the hydraucone action.

That the resulting loss of the hydraucone action is of less magnitude than the gain due to the ejector effect is proved by tests which show that the draft-tube efficiencies with this type of hydraucone-chamber construction increase as the gate is closed.

While the hydraucone action of the water was the cause for the particular design of Mr. White's, the writer believes that the design has won merit far more because of its ejector action than its hydraucone qualities, in so far as the hydraucone qualities have to do with a regain in the hydraucone chamber, especially under whirling conditions.

An interesting coincidence is to be noted with regard to the surging and other noises within the draft tube at different gates. In

connection with the pitot-tube traverses, the corresponding surging or rattling within the tube was noted for the different gates:

0.1 gate	Light surging as if made by small amount of water
0.2 gate	About same as 0.1 gate
0.3 gate	Surging 64 times per minute. Runner rattles
0.4 gate	Same as 0.3
0.5 gate	Surging partly ceased. Pitot tube vibrates
0.6 gate	Surging 72 times per min. Not so loud. No rattling of pitot tube
0.7 gate	Steady flow
0.8 gate	Steady flow
0.9 gate	Steady flow
Full gate	Steady flow.

It is interesting to note that the upward column of water begins to be very small at 0.7 gate. At this gate the surging ceases and steady flow is maintained.

Suggesting a cause for surging at lower gates, it may be said that the tube is not full of water. Then, if the turbine gates close a slight amount suddenly, the vacuum under the runner may lift the volume of water, which partially fills the tube, up toward the

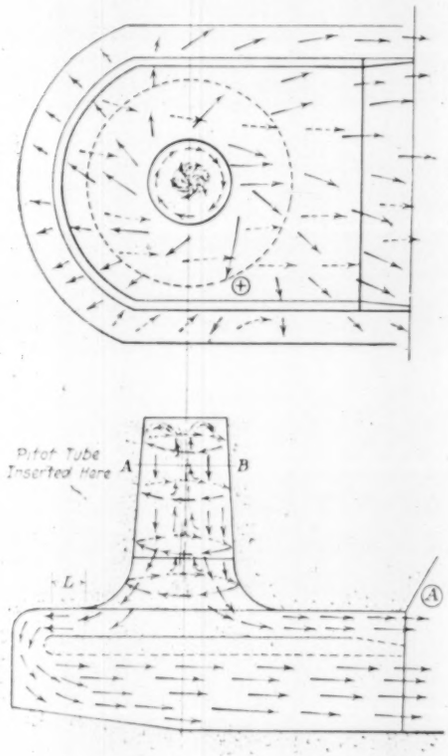

FIG. 8 ACTION OF WATER IN THE GREGGS FALLS TUBE

runner. The water, falling back again, may readily set up an oscillating movement which will continue until an equal force in the opposite direction happens to occur by the sudden partial closing of the gates as the surface of the oscillating volume of water is on the down "stroke."

Whatever the cause, it is certain that such surging is highly undesirable in that it causes an uneven pressure on the runner, thus imposing added duty on the governor and greater strains on the runner and penstock.

WHITE LOW-HEAD HYDRAUCONE REGAINER

Fig. 9 shows the White design for low-head installations. The base of the hydraucone chamber in this case is the bottom of the excavation, the collecting chamber being above the table top rather than below. This design may be used for extreme low-head installations. The space marked *s* on this plate corresponds to the space (3) in Fig. 5.

Horizontal turbines have been usually arranged to discharge the water into a sharp 90-deg. elbow placed at the top of a vertical draft tube. From what has been already said concerning the gyroscopic action of the whirling water, it may be readily seen that very poor draft-tube efficiencies are to be had with a sharp bend so close to the runner. The advantages of the hydraucone chamber draft tube on such horizontal turbines are obvious.

THE MOODY SPREADING DRAFT TUBE

Mr. L. F. Moody, consulting engineer of the I. P. Morris department of the Wm. Cramp & Sons Ship and Engine Building Company at Philadelphia, has designed a draft tube which, at first glance, bears a striking resemblance to the low-head design by Mr. White.

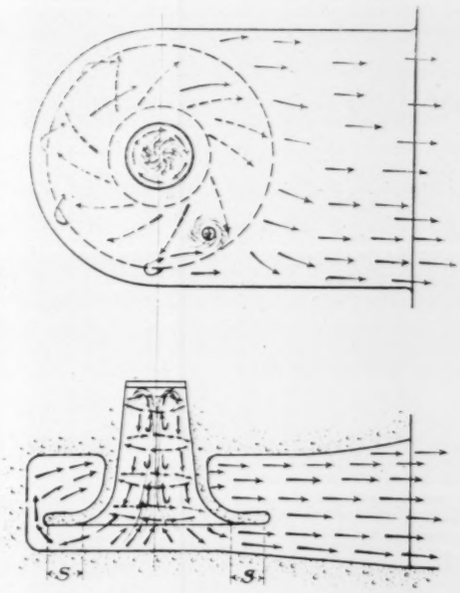

FIG. 9 WHITE LOW-HEAD HYDRAUCONE REGAINER

See Figs. 9 and 10. The two designs appear to be practically identical, with the exception of the concrete cone in the Moody design. There is, however, a radical difference in the principles upon which the tubes are based.

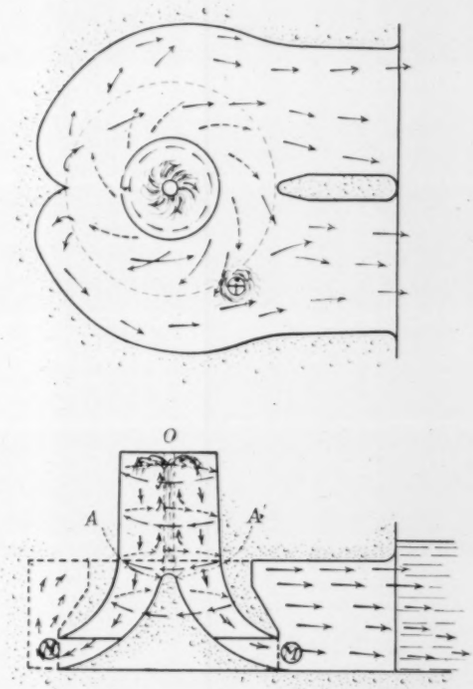

FIG. 10 THE MOODY SPREADING DRAFT TUBE

The Moody spreading draft tube is based on the principle illustrated by the familiar case of a free vortex in an open basin. Fig. 11 is a diagram of a cross-section through a free vortex. The water, as it whirls through the opening *OS*, assumes a definite shape

as shown by the solid lines *ABCDEFGH*. Mr. Moody has shown, with reference to the free flow of water through a space of revolution, that the velocity of whirl varies inversely as the radius and that the corresponding velocity head varies inversely as the square of the radius. If it is assumed, for instance, that the particle *x* is on the surface at *A*, it will increase its velocity of whirl as it approaches *CD* where the radius is smallest. The smaller the radius, the greater the velocity of whirl.

Since the reverse conditions hold—the greater the radius, the less the velocity of whirl—it occurred to Mr. Moody that if the water could be conducted even but a short distance away from the central axis of the draft tube without incurring eddy losses, the velocity of whirl of the water discharging from the runner could be effectively regained into static head. In other words, if the

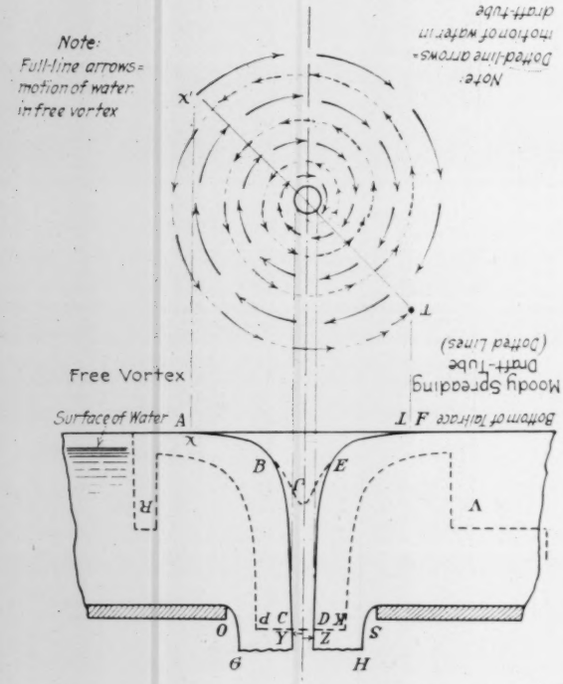

FIG. 11 PRINCIPLE OF FREE VORTEX ON WHICH MOODY TUBE IS BASED

action of the free vortex could be reversed, the regain could be accomplished.

Turn Fig. 11 upside down and consider the conditions now as reversed. The hole *OS* is discharging water which is whirling at high velocity as shown by the dash and double-dot lines in the lower drawing. Assume that the particle *Z* is moving toward *T*. The greater its radius, with respect to the axis, the slower its velocity. Thus it is evident that the required effect is produced. It now remains to suitably enclose the whirling water and conduct it far enough away from the axis to give the desired reduction in velocity.

The dotted lines in this figure represent an enclosed reversed vortex. The outline is that of the Moody spreading draft tube as installed at Niagara Falls. The concrete cone *TJX* does not fill the entire space which would occur in the case of a free vortex, because such a structure in a tube of this size would be unstable. However, it is recommended that the cone be carried up to the runner in all cases where practicable. The space *RV* is the collecting chamber into which the draft tube discharges.

Now if it is considered that a turbine runner is discharging water with a high velocity of whirl at *KP*, the water will flow spirally around the circumference of the tube, steadily decreasing its velocity as it increases its distance radially from the axis in accordance with the law previously explained. Thus the Moody spreading draft tube, based on the principle of the free vortex, regains static head from velocity of whirl as well as from velocity of discharge.

CONCLUSIONS

The extremely low-head installations which are now being considered have made it necessary to investigate thoroughly a method of regaining all the draft head possible. Since a low-head plant requires a runner of high specific speed, and therefore a high exit velocity from the runner, it is evident that the question of converting velocity head of the water revolving at high speed into static head is a question of great importance. Generally, when low-head plants are built, the expense of excavating for a long draft tube would be prohibitive; hence some form of radial draft tube is preferable.

The tests on the radial tubes as against the older designs prove conclusively that the radial type is a long step forward.

The writer suggests that an investigation as to the operation of both designs under service conditions be made before attempting a conclusion as to which of the two radial tubes is the better. It is further suggested that the investigation include some data as to the cost of construction of each form.

DISCUSSION

The discussion of Mr. Ramsey's paper was opened by Lewis F. Moody,[1] who complimented the author on his splendid paper upon which a very large amount of thought and study had been expended.

S. Logan Kerr,[2] showed a large number of slides, principally of spreading draft tubes, and including those at the 30,000-hp. plant at Muscle Shoals, Ala., the 37,000-hp. plant at Niagara Falls, and the 55,000-hp. unit of the Hydroelectric Power Commission. Mr. Ramsey had said that the Moody tube was particularly adaptable to low-head plants, but in one of the highest-head plants, 680 ft., a unit had recently been placed in operation and tested with the spreading tube with absolutely no vibration at any gate. In other words, the whirling component is prevented in the spreading tube, which is equally adaptable to the low-head or high-head plants.

H. Birchard Taylor[3] said that, relative to the subject of spreading tubes when used with high heads, it had been his experience that vibration was due to the condition in the penstock resulting in instantaneous action, and did not properly enter the question of efficiency.

Discussing Mr. Lyon's paper, which was presented after Mr. Ramsey's paper and which follows directly in this issue, R. L. Daugherty[4] said that results of tests he had made at Cornell University some four years previously agreed fairly well with those of Mr. Lyon. He had at that time tried the device of putting in a false floor in the bottom of the tail race so that it could be raised higher and higher and brought close to the mouth of the draft tube. When it was brought within $^5/_{16}$ in. and $1^1/_4$ in. from the end of the tube there was a persistent pressure instead of a suction. When the false floor was a distance from the end of the draft tube equal to a quarter of its diameter, the efficiency was a maximum.

DISCUSSION OF PAPER ON VERTICAL TRIPLE-EXPANSION PUMPING ENGINE

(Continued from page 161)

motor-driven centrifugal pumps had been operated in Indianapolis for over two years and that the efficiency, as determined by frequent tests, had not fallen off from the 86 per cent given when first installed.

As to first cost, the geared-turbine-driven centrifugal pump occupied but from $^1/_5$ to $^1/_6$ the cubical space of a triple-expansion engine of the same capacity. This made a very great difference in the cost of labor and material for building and foundations.

As to cost of upkeep, the first large gear-driven pump for water-works service was installed in Pittsburgh some ten years ago. It was still running, and there had never been any change in the gears or repairs made to the turbine.

As to the steady running of gears, none of the water-works gears had given any trouble, and there were something like 50 large units now in operation.

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[1] Asst. to Vice President, William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa.

[2] I. P. Morris Department, William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa.

[3] Vice-President, William Cramp & Sons Ship & Engine Building Company, Philadelphia, Pa.

[4] Prof. Mech. and Hyd. Engr., California Institute of Technology.

Flow in Conical Draft Tubes of Varying Angles

By GEORGE E. LYON,[1] TROY, N. Y.

THE purpose of this investigation was primarily to determine the velocity curves at several cross-sections of straight conical draft tubes. This is of importance as the results will show the flow and its variation along the tube. Incidentally the efficiencies of all but one of the tubes were found.

The function of the draft tube is twofold: first, to produce a suction under the turbine equal to the elevation of the turbine above tail water; second, to regain the kinetic energy of the water as it leaves the turbine. A plain cylindrical tube would meet the first requirement provided its mouth was submerged to exclude the air. It is of far greater importance, however, that the second requirement be fulfilled. The high-speed, high-capacity hydraulic turbine of today, operating under low head discharges water with as much as 25 to 30 per cent of the initial energy of the water in kinetic energy at discharge. Hence it may be seen that without an efficient draft tube the development of much of the potential water power under low head would be seriously handicapped. It is in the design of draft tubes operating under conditions mentioned above that the importance of this investigation may be realized; for, having found the character of flow, a tube may be designed to be more efficient in regaining kinetic energy. Heretofore nothing has been done in the way of finding the character of flow in diverging tubes.

For this thesis experiments were performed on seven draft tubes. All of the tubes were 3 in. in diameter at the throat, five enlarging to 6 in. at the mouth and two to 9 in.

One tube was of concrete, the others being made of heavy galvanized iron. The angle between opposite elements varied from 4 to 12 deg. Velocity traverses were made in each tube at four cross-sections, including the throat and mouth and at three rates of discharge. The efficiencies of all but one of the tubes were found.

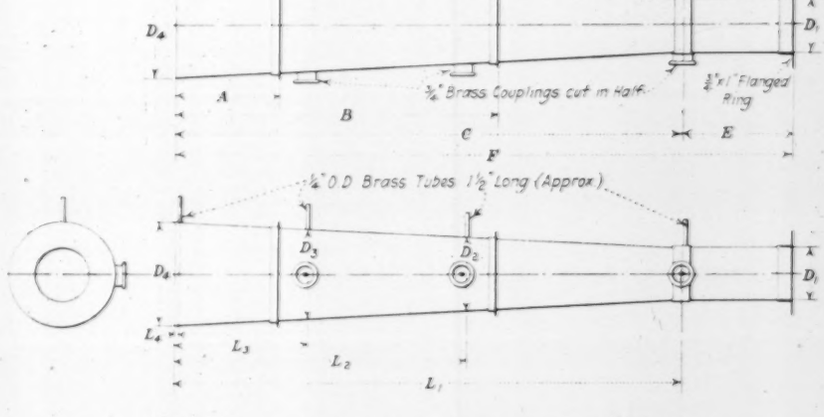
This investigation was conducted in the hydraulic laboratory of the Russell Sage Laboratory, Rensselaer Polytechnic Institute Troy, N. Y., during the school year ending June, 1921.

Water for the tests was pumped from a large cistern under the hydraulic laboratory by means of a 6-in. Lawrence double-suction centrifugal pump (1000 gal. per min.) direct-connected to an Allis-Chalmers d.c. motor. The water was pumped into a large tank overhead, from which it discharged through an 18-in. tee into a 5-in. pipe and thence into a 3-in. pipe through a 3-in. gate valve. After discharging through the draft tube into the concrete-lined flume 30 in. wide by 18 in. deep and containing baffles for smoothing the flow, the water passed over a suppressed weir into the cistern below.

The first draft tube (A) was made of concrete, about one part cement to three parts sand. It was formed by pouring the concrete around a wood core in an 8-in. pipe 4 ft. long. The wood core was represented by a cylinder 3 in. in diameter by 5 in. long on the top of a truncated cone having a diameter of 3 in. at the top and 6 in. at the bottom in a length of 43 in. This gave an angle of 4 deg. between sides. This form of tube was very inconvenient, causing trouble in removing the core, also it was very heavy. The rest of the tubes, six in number, were made of galvanized iron and of the dimensions given in Fig. 1. Brass couplings (3/4-in.) were soldered to the draft tubes over openings large enough to pass the pitot tube through. These were spaced at equal intervals of cross-sectional area of the draft tubes. The upper section being at the throat and the lower one 1/4 in. above the mouth. At these four sections piezometer connections were made of 1/4 in. brass tubes soldered to the draft tubes and at 90 deg. from the pitot-tube connections. These tubes were connected so that the finish was perfectly flush with the inner surface of the draft tubes.

The Tests

Tests were made at three rates of discharge; 0.985, 0.745, and 0.476 sec-ft. The high rate for draft tube "E" was taken at 0.947 sec-ft. instead of 0.985 sec-ft. All tests were duplicated. Readings were taken at eleven (sometimes thirteen) points on each diameter. The points were taken closer together at the sides of the tube, spreading out toward the center. In the traverses taken at the throat sections, the throat pressure and tail-water gages were also read, just before taking the pitot-tube readings.



TUBE	ANGLE BETWEEN SIDES	A	B	C	E	F	D_1	D_2	D_3	D_4	L_1	L_2	L_3	L_4
B	6°	6"	18½	28.62	6"	34.62	2.96	4.25	5.20	5.98	30.19	16.77	7.62	¼
C	8°	4½	14½	21.25	13.17	34.62	2.92	4.24	5.22	6.00	21.13	12.56	5.75	¼
D	10°	3	11¾	17.14	17.48	34.62	2.94	4.24	5.24	5.96	17.33	10.02	4.52	¼
E	12°	2	6½	14.27	20.35	34.62	3.00	4.25	5.22	6.00	14.55	9.36	3.82	¼
F	8°	8	20½	42.90	4.35	47.25	3.00	5.76	7.54	9.04	43.40	23.25	10.45	¼
G	10°	6	16½	34.28	12.97	47.25	2.96	5.74	7.60	9.00	34.75	18.56	8.10	¼

Note: Material No. 26 Gal. Iron

FIG. 1 DIMENSIONS OF DRAFT TUBES TESTED

Column 1 of the notes (Table 1) gives the radius from the center of the draft tube to the impact orifice of the pitot tube in inches. All readings between the two L's being taken on the left of the center line and those between the two R's on the right. Column 2 gives the piezometer readings in inches. In the next column are the pitot-tube readings in inches. These were omitted when the mercury manometer was used. Next are the differences in inches marked y or h for mercury or water, respectively. The next column gives the velocities in feet per second computed from y or h, and the last column gives the hook-gage readings in feet. The zero of the hook gage was 0.766 ft. and the readings for the rates of discharge were (see above) 1.112 ft., 0.961 ft., and 0.910 ft., respectively. For the high rate of draft tube "E" the reading was 1.000 ft. Whenever readings were taken at other rates of discharge, the velocity tabulated is that found by correcting the calculated velocity in the ratio of the discharge. The variation in discharge, however, was quite small. The notes taken at the throat sections contain two additional columns. One marked "Flume" gives the reading of the tail water in inches and the other marked "Piezometer" gives the throat piezometer reading in inches. The average difference of these two columns gives the negative pressure at the throat due to the regain of kinetic energy.

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Abstract of a thesis submitted to the trustees and faculty of Rensselaer Polytechnic Institute in conformity with the requirements for the degree of Doctor of Engineering, June, 1921, and presented at the student Session of the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 8, 1921. All papers are subject to revision.

COMPUTATIONS

Reduction of mercury readings (y) for velocity:

$v = c\sqrt{2g(13.6-1)y/12} = 1.007\sqrt{2\times 32.2\times 12.6\, y/12} = 8.276\sqrt{y}$

for pitot tube No. 1.

Reduction of water readings (h) for velocity.

$v = c\sqrt{2gh/12} = 1.007\sqrt{2\times 32.2\, h/12} = 2.331\sqrt{h}$ (tube No. 1)

$v = c\sqrt{2gh/12} = 1.000\sqrt{2\times 32.2\, h/12} = 2.316\sqrt{h}$ (tube No. 2)

The following will serve to indicate in detail the computations, test D-1 (in Table 1) being selected.

From the piezometer reading of 54.20 in. on the mercury manometer by previous calibration the difference between the piezometer and pitot-tube readings is calculated to be 4.51 in. The

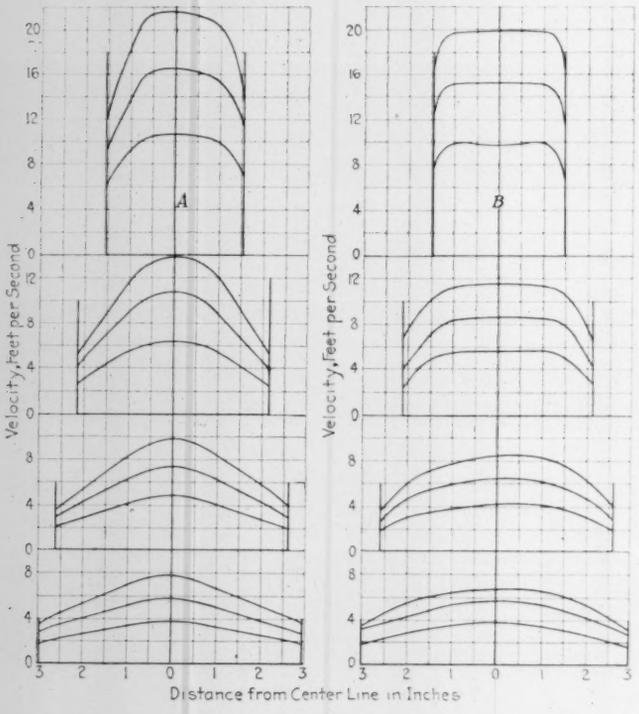

FIG. 2 VELOCITY CURVES OF DRAFT TUBES A AND B

zero reading for these two tubes is 51.90 in., but as the bore was not the same, a slight correction was introduced. $v = 8.276\sqrt{y} = 8.276\sqrt{4.51} = 17.58$ ft. per sec.

After plotting the velocity curves against radius, the moment of this area was found to check the discharge and the per cent error e tabulated in Tables 2 and 3. As will be explained later, the moment of the v-r curve is equal to $Q/2\pi$. $e = 100\,(Q-Q_0)/Q_0$, where Q is the discharge by integrating velocity curve and Q_0 is the discharge by weir which is taken as being correct. For tests D-1 and D-2, $e = 2.2$ per cent.

The average difference of the last two columns of tests D-1 and D-2 gives the negative pressure head in inches at the throat due to regain and is tabulated in Table 2 under "$-p$." In this case $-p = 60.96$ in. From the velocity curve plotted from these tests (Fig. 3) the kinetic-energy curve was constructed by plotting v^3 against r^2. The area under this curve is the kinetic energy possessed by the water at the throat section. In this case K.E./sec. = 394.0 ft. lb.

$$\text{The mean velocity head} = \frac{v^2}{2g} = \frac{\text{K.E.}}{\text{sec.}}\,\frac{1}{wQ_0}\,\frac{1}{(1+e)^3}$$

$$= \frac{394.0}{62.4\times 0.985}\,\frac{1}{(1.022)^3} = 6.01 \text{ ft.}$$

$$\text{The efficiency of regain} = \frac{60.96}{12\times 6.01} = 84.5 \text{ per cent.}$$

Values of $\frac{\text{K.E.}}{\text{sec.}}$, $\frac{V^2}{2g}$ and efficiency may be found in Table 2.

Consider test B-12 in which the hook gage regaging was 1.003 ft. instead of 1.002 ft.

TABLE 1 SAMPLE NOTES

Rad. to pitot	Piezometer	Pitot tube	Diff. $=h$	Vel.	Hook gage	Remarks
2.90L	46.50	48.90	2.40	3.58	1.003	Test B-12
2.75	46.10	49.50	3.40	4.25	1.003	
2.50	45.75	50.10	4.35	4.78	1.004	5.98 in. Section
1.75	44.80	51.90	7.10	6.15	1.003	
0.75L	44.20	52.90	8.70	6.76	1.004	Cent. pump
0	43.95	53.35	9.40	7.07	1.003	used.
0.75R	44.15	53.00	8.85	6.86	1.003	
1.75	44.95	51.60	6.65	5.95	1.003	Water gage
2.50	46.10	49.60	3.50	4.32	1.003	used.
2.75	46.45	48.95	2.50	3.65	1.003	
2.90R	46.60	48.75	2.15	3.40	1.002	

Rad. to pitot	Piezometer	Diff. $=y$	Vel.	Hook gage	Flume	Piezometer	Remarks
1.42L	54.20	4.51	17.58	1.002	70.2	6.5	Test D-1
1.32	54.85	5.81	19.95	1.002	70.7	5.9	
1.17	55.20	6.47	21.03	1.002	70.0	6.7	2.94 in. Section
0.92	55.35	6.75	21.50	1.002	68.7	6.2	
0.62L	55.30	6.66	21.35	1.002	68.8	6.1	Cent. pump
0	55.30	6.66	21.35	1.002	72.0?	1.0?	used.
0.62R	55.30	6.66	21.35	1.002	66.0	7.2	
0.92	55.25	6.57	21.20	1.002	66.4	6.5	Hg. gage used.
1.17	55.10	6.29	20.77	1.002	66.7	6.3	
1.32	54.70	5.51	19.42	1.002	66.5	6.6	
1.42R	54.25	4.61	17.77	1.002	66.7	6.3	
1.42L	54.20	4.51	17.58	1.002	67.2	4.8	Test D-2
1.32	54.75	5.61	19.60	1.002	66.2	7.0	
1.17	55.10	6.29	20.77	1.002	66.8	6.0	2.94 in. Section
0.92	55.25	6.57	21.20	1.002	66.7	6.2	
0.62L	55.25	6.57	21.20	1.002	66.2	7.1	Cent. pump
0	55.25	6.57	21.20	1.002	66.4	6.9	used.
0.62R	55.25	6.57	21.20	1.002	66.8	6.2	
0.92	55.25	6.57	21.20	1.002	66.3	7.0	Hg. gage used.
1.17	55.10	6.29	20.77	1.002	66.7	6.5	
1.32	54.70	5.51	19.42	1.002	67.1	6.0	
1.42R	54.10	4.31	17.20	1.002	67.1	6.0	

The difference $h = 2.40$ in.

$$v = 2.316\sqrt{2.40}\times\frac{0.985}{0.990} = 3.58 \text{ ft. per sec.}$$

0.985 = discharge for hook-gage reading of 1.002 ft. (standard)

0.990 = discharge for hook-gage reading of 1.003 ft.

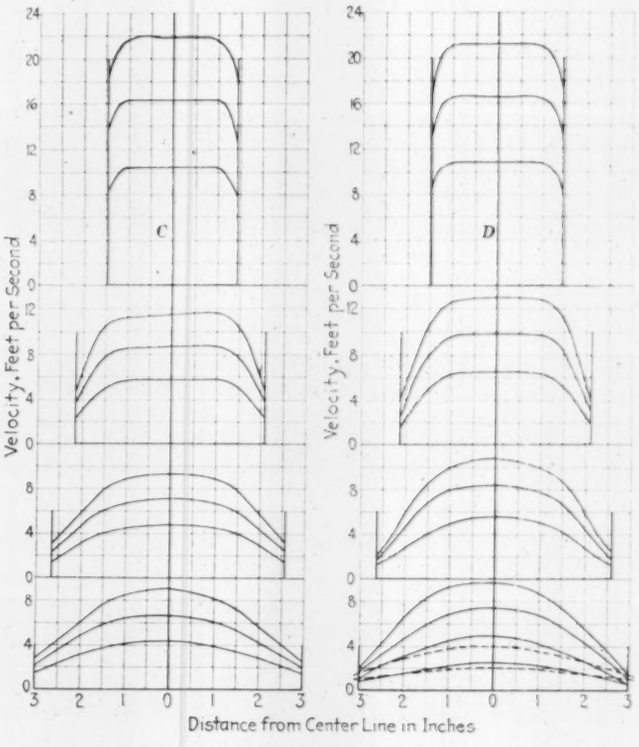

FIG. 3 VELOCITY CURVES OF DRAFT TUBES C AND D

At this section the diameter on which the readings were taken did not equal the mean diameter. Hence upon integrating for discharge, the result was modified by multiplying by $\left(\frac{5.98}{6.00}\right)^2$ and the error (e) computed after this correction was made.

The various formulas which are mentioned above are derived as follows:

1 The moment of the area of a v-r curve about the center line is equal to the volume of water per second divided by 2π. Let r = radius in feet corresponding to the velocity in feet per second on

TABLE 2 THROAT SECTIONS

Draft tube	Qo sec-ft.	e per cent	−p in.	K.E.	$V^2/2g$ ft.	Effy per cent
A	0.985	−2.7	—	—	—	—
A	0.745	−1.1	—	—	—	—
A	0.476	−1.3	—	—	—	—
B	0.985	−5.3	62.18	331.5	6.35	81.6
B	0.745	−3.0	35.30	146.7	3.46	85.0
B	0.476	−3.8	14.58	39.8	1.51	80.6
C	0.985	−0.6	68.06	424.5	7.04	80.7
C	0.745	+1.2	39.76	178.3	3.71	89.3
C	0.476	−0.2	15.86	46.2	1.567	84.3
D	0.985	+2.2	60.96	394.0	6.01	84.5
D	0.745	+2.0	38.33	188.8	3.68	87.0
D	0.476	+4.0	16.20	52.2	1.566	86.2
E	0.974	+4.5	57.49	394.0	5.69	78.5
E	0.745	+3.9	32.37	173.2	3.33	81.0
E	0.476	+2.1	13.85	46.4	1.475	78.4
F	0.985	−3.6	68.60	344.0	6.25	91.5
F	0.745	−8.9	38.28	123.7	3.52	90.7
F	0.476	−3.4	15.75	38.4	1.437	91.4
G	0.985	−6.7	58.54	316.5	6.35	77.0
G	0.745	−6.0	32.28	133.0	3.44	78.2
G	0.476	−7.1	13.18	33.6	1.41	77.8

TABLE 3 VALUES OF e FOR SECTIONS BELOW THROAT

Draft tube	1st Sect. below throat	2nd Sect. below throat	Sect. at mouth	Q Sec-ft.
A	−7.1	−4.5	+0.5	0.985
A	−3.9	−2.3	+1.9	0.745
A	−2.5	−3.4	+0.8	0.476
B	−1.3	−2.6	+1.7	0.985
B	−4.0	−3.1	+6.6	0.745
B	−2.9	+0.2	+4.4	0.476
C	—	−2.6	+3.7	0.985
C	—	−2.8	+8.7	0.745
C	—	+1.3	+9.4	0.476
D	−1.4	+1.5	+6.6	0.985
D	−2.2	+4.8	+4.8	0.745
D	−1.3	+0.8	+7.7	0.476
E	−0.8	+0.1	+6.7	0.974
E	+0.4	−0.1	+5.4	0.745
E	+1.5	+3.8	+5.7	0.476
F	−2.4	−2.7	+5.6	0.985
F	−2.3	−1.7	+7.2	0.745
F	−2.6	+0.6	—	0.476
G	−3.6	−8.4	+6.8	0.985
G	−1.3	−3.5	+4.0	0.745
G	−1.5	+4.2	—	0.476

the v-r curve. Then Q = discharge in cubic feet per second

$$= \int_0^r v 2\pi r dr = 2\pi \int_0^r r v dr.$$

But rdr is d (area) under curve, and $rvdr$ is the moment of this area about the center line. Performing the integration:

Q = $2\pi \times$ moment of half-area about center line

= $\pi \times$ sum of the moments of the two half-areas about the center line.

2 The efficiency of a draft tube as a regainer of kinetic energy may be determined as follows:

Consider a draft tube as shown in Fig. 4, and that the upper tank

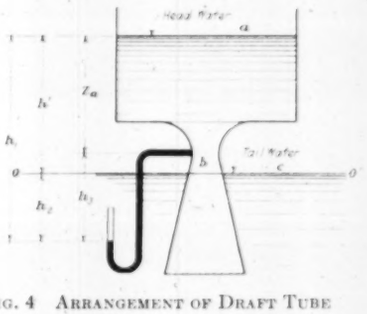

FIG. 4 ARRANGEMENT OF DRAFT TUBE

is raised or lowered until the head h' is sufficient to overcome the losses at a given rate of flow. Thus h' is the total loss. The velocity head in the upper tank is assumed to equal zero and there is no loss down to the throat of the draft tube. Then

$$p_a + z_a = p_b + \frac{V_b^2}{2g} \text{ or } \frac{V_b^2}{2g} = z_a - p_b + p_a.$$

Now

$$p_b = -h_3 + p_a \text{ and } p_a = 0 \therefore \frac{V_b^2}{2g} = h_1$$

Now h' represents the loss, so that the efficiency of a draft tube as a regainer of kinetic energy

$$= \frac{\frac{V_b^2}{2g} - h'}{\frac{V_b^2}{2g}} = \frac{-h_2}{h_1}$$

Readings are referred to atmospheric pressure as a datum. h_2 is negative as the zero of the gage board is at $O-O'$, the surface of tail water, and hence $\frac{-h_2}{V_b^2/2g}$ is positive.

Where there is a loss between a and b the efficiency can not be found by simply taking the readings h_1 and h_2. In this case the reading h_1 must be replaced by $V_b^2/2g$ determined from the velocity traverse taken at this section. This was the method used in this investigation.

Kinetic energy per second = K.E./sec. = $Wv^2/2g$

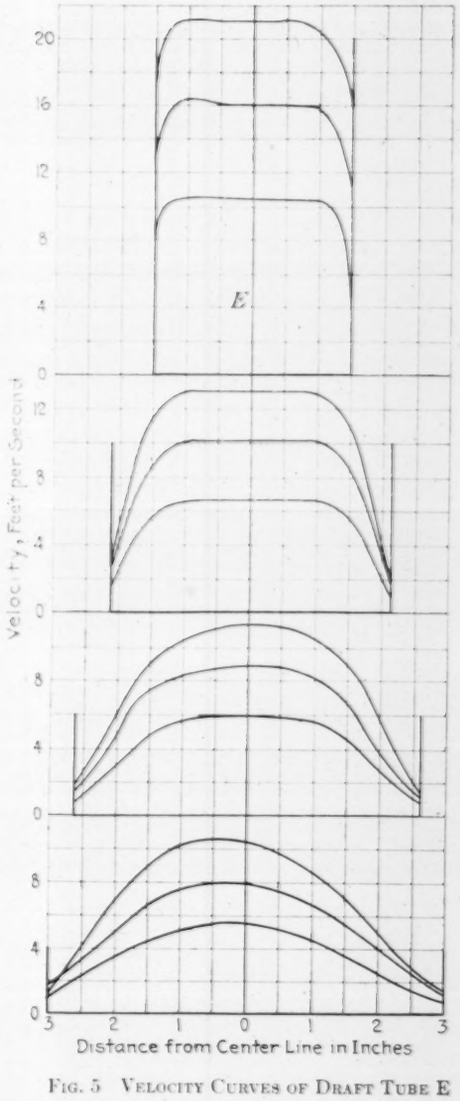

FIG. 5 VELOCITY CURVES OF DRAFT TUBE E

$W = \int_0^r w v 2\pi r dr$, where w = density of water

$$\frac{\text{K.E.}}{\text{sec.}} = \int_0^r \frac{1}{2}\frac{v^2}{g} 2w\pi r v dr = \frac{w}{2g}\int_0^r v^3 2r dr = \frac{w\pi}{2g}\int_0^r v^3 d(r^2)$$

Hence the area under the v^3r^2-curve multiplied by $\frac{w\pi}{2g}$ equals the kinetic energy.

To get $V_b^2/2g$, divide by W, since head is the amount of energy per pound of water.

$$\therefore \frac{V_b^2}{2g} = \frac{\text{K.E./sec.}}{W} = \frac{\text{K.E./sec.}}{wQ}$$

Due to the error e found by checking the velocity curves against the weir for discharge, a correction was applied to the velocity head $V_b^2/2g$ just found. This correction is based on the assumption that the velocities found from the pitot-tube traverse must be increased or decreased proportionally so that the discharge found by the "moment" method equals that found by the weir. It will be seen that this is equivalent to changing the constant for the pitot tube.

Let Q_0 = discharge by weir (assumed to be correct)

Q = discharge found by taking the moment of the v-r curve

$Q_0 = kQ$

$$\text{Error} = e = \frac{Q - Q_0}{Q_0} = \frac{1}{k} - 1$$

$$Q = AV \quad Q_0 = AV_0 \quad \therefore \quad \frac{Q}{Q_0} \frac{V}{V_0} \frac{1}{k}$$

where v = pitot-tube velocity and v_0 = corrected velocity.

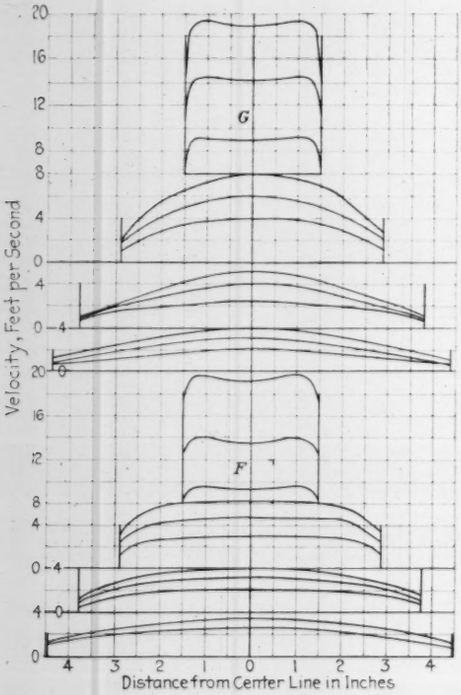

Fig. 6 Velocity Curves of Draft Tubes F and G

Let K.E. = kinetic energy from v^3r^2-curve.

K.E. = theoretical kinetic energy from $v_0^3r^2$-curve (if such curve were plotted)

$$\text{As before K.E.} = \frac{1}{2}\int_0^r \frac{v^2}{g}\, 2w\pi rv dr$$

$$\text{K.E.}_0 = \frac{1}{2}\int_0^r \frac{v_0^2}{g}\, 2w\pi rv_0 dr = \frac{1}{2}\int_0^r \frac{k^2v^2}{g}\, 2w\pi rkv dr$$

$$\therefore \quad \text{K.E.}_0 = k^3\text{K.E.}$$

and

$$\frac{v_0^2}{2g} = \frac{\text{K.E.}_0}{wQ_0} = \frac{k^3\,\text{K.E.}}{wQ_0} = \frac{\text{K.E.}}{wQ_0}\,\frac{1}{(1+e)^3}$$

since

$$k = \frac{1}{(1+e)}$$

Each velocity curve (Figs. 2, 3, 5 and 6) represents the results of two individual traverses or tests. Hence for the 86 curves shown, 172 tests were made. Two additional tests, D-25 and D-26, were made at the mouth of draft tube "D" at a discharge of 0.223 cu. ft. per sec. (hook gage = 1.851 ft.). This is the lowest full-line curve plotted under "D" (Fig. 3). Four more tests, D-27, D-28, D-29 and D-30, were made 6 in. below the mouth of draft tube "D;" the first two at 0.476 sec-ft. and the last two at 0.985 sec-ft. These two curves are shown by the dotted lines (Fig. 3). For the piezometer reading, the flume connection was used. The efficiency curves (Fig. 7) were plotted on a base of average velocity.

The velocity curves for the throat section of draft tube "A" were so distorted it was thought that a sudden enlargement to reduce the velocity would permit the water to be drawn off in a smoother stream-line flow. Accordingly the section of 8-in. pipe with bell mouth at bottom to meet the 3-in. section was introduced. The effect of this was very noticeable, as the curves for the remaining tubes were very nearly symmetrical.

With a couple of exceptions, the curves indicate:

1 That the velocity at the throat (before the water enters the flare) is uniform, falling off at the walls.

2 That this uniform velocity breaks down at the sides of the diverging tube first and gradually falls off nearer and nearer the center. The curves for the first section below the throat indicate this.

3 That some distance down in the draft tube, the uniform velocity which persisted at the center finally disappears and the velocity curve becomes peaked at the center.

4 That this peaked curve persists down the rest of the tube, flattening out somewhat toward the mouth, but even there having a center velocity of from twice to five times the wall velocity.

5 That this ratio of center velocity to wall velocity increases with the angle of flare.

6 That at a distance below the mouth of the draft tube equal to the diameter at this point, the curve remains peaked. This is only based on the four under water traverses below draft tube "D."

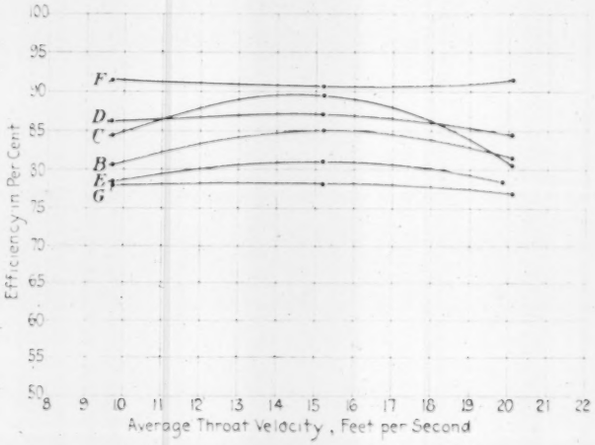

Fig. 7 Efficiency Curves of Draft Tubes

"Lateral flow," the motion of the water due to the flare, appears to be greatest near the wall, breaking down the velocity curve very greatly here. Its effect at the center of the tube is more gradual and, at first, uniform.

At the end of the tests the impact orifice in pitot tube No. 1 was plugged and a small hole drilled in the side. A traverse (Table 4) was made, referring the pitot-tube readings to the piezometer at the wall of the tube. It will be seen that the pitot tube records a lower reading than the piezometer. This is not due to whirl as the differences are all negative. The curvature of the pitot tube would not permit its side orifice to record true pressure.

TABLE 4 TRAVERSE DRAFT TUBE "D," 4.24-IN. SECTION

Rad. to pitot	Piezometer	Tube press.	Diff.	Hook gage
2.02L	42.75	42.30	−0.45	0.910
1.92	42.85	42.10	−0.75	0.910
1.72	43.15	41.70	−1.45	0.910
1.42	43.50	41.10	−2.40	0.910
0.82L	43.60	40.90	−2.70	0.910
0	43.65	40.85	−2.80	0.910
0.82R	43.60	41.00	−2.60	0.910
1.42	43.40	41.40	−2.00	0.910
1.72	43.20	41.90	−1.30	0.910
1.92	43.00	42.30	−0.70	0.910
2.02R	42.85	42.60	−0.25	0.910

It would be of interest in the future to conduct tests under very low rates of discharge, also to determine whether or not there is a variation of pressure across a section.

Science in the Textile Industry

THE Textile Division of The American Society of Mechanical Engineers is endeavoring to direct the thought of the textile industry into scientific and engineering channels. In textile manufacturing, as in many other industries, there has heretofore been a great deal of empiricism. This has been notably the case in England where the industry has been built up on a great deal of tradition, and where very little fact has been used in many of the textile-manufacturing processes.

To the end of developing this kind of thought, the Textile Division held an important meeting in New York on the occasion of the Annual Meeting of the Society on Friday, December 9, 1921. The papers presented and the discussion which followed certainly confirmed the viewpoint that research work in the textile industry must be conducted on the basis that the engineering principles of every existing process must be suspected until research work has demonstrated that they are founded on fact.

British cotton manufacturers have just contributed $1,000,000 for the conduct of broad research work in the textile industry. This was brought out at the meeting by Charles T. Main of Boston, Past-President of the Society, who presented a report of the delegates of the Society to the Second World Cotton Conference at Manchester, England, in July, 1921. In the opinion of Mr. Main, this is a lesson for American manufacturers, who naturally pride themselves upon their openmindedness, and who will wish to keep abreast of their brothers across the sea.

The two technical papers presented at the session were Hidden Wastes in Textile Plants, by T. P. Gates, and Economy in Textile Drying, by B. R. Andrews. The first of these papers pointed out a few of the losses found in the average textile plant which have been largely overlooked, and which can be greatly reduced through the application of engineering research. The second enunciated the principles of satisfactory and economical drying, with reduced labor costs and minimum steam consumption. These papers are reprinted below.

Hidden Wastes in Textile Plants

By THAYER P. GATES,[1] PROVIDENCE, R. I.

THE purpose of this paper is to point out a few of the losses found in the average textile plant which have been very largely overlooked and which can be greatly reduced through the application of engineering research. The types of losses considered are mainly those occurring in the operation of equipment and the utilization of materials. The paper also points out the opportunities in the textile field for men of engineering training.

The essentials in any study on the elimination of waste are:

a to determine the facts of present operation

b to determine what new facts may be found by analysis or research

c to apply these facts to the improvement of operation.

Examples of Methods Employed in Elimination of Waste in Textile Mills

As an example of this method in the study of the operation of equipment, the output from a water mangle as used in cloth-finishing plants may be used. Knowing the present output of the machine, the first step would be to determine the maximum speed at which the machine would operate mechanically, allowing of course a proper factor of safety at the weakest point, and then find whether the goods could be put through the machine at that speed consistent with proper quality.

In such a study it may be found that the cloth will not open to width from the rope form at the required speed because the beaters on the scutcher will not take care of it properly. This involves experimental study by the engineer to determine changes necessary on this scutcher to take the increased output.

Then it may be found that the goods are damaged on the expander. The questions are immediately asked: at what place on the expander? what are the reasons for the damage? and how can the difficulty be eliminated? Another job for the engineer. Further, it may be found that the plaiter will not deliver the goods into the truck at the new speed. The engineer again asks why, and by proceeding to overcome this difficulty by employing the methods of engineering research to solve these problems, one at a time, the maximum capacity of the machine is finally reached. In many instances the output as a result of these studies is more than doubled, and the failure to take advantage of this possible increase constitutes a larger "hidden waste."

In many plants chemical problems may limit the output. As it is usually possible to redesign the mechanical equipment to take care of the maximum output from the chemical standpoint, the first research work should be done in the chemical laboratory. The problem is to determine what are the variables, and then to solve these variables for the best result of each when combined with each other. This involves the determination of a unit which must be applied in measuring and standardizing each variable.

For example, in the determination of luster on a mercerized fabric the standard unit should be saturation, which is measured by shrinkage of the cloth when submerged in caustic. In bleaching, the standard unit is the degree of whiteness combined with the strength and aging qualities of the goods bleached. The chemical research having been completed, the engineer must take these facts and apply them to the study of the equipment to give the maximum output.

The first experience of the author with textile research came when he was engineer of a large finishing plant. One of his problems was to locate a new bleach house to take care of approximately 50 per cent increase in production. A careful study failed to reveal any place where the building could be located and any continuity of the processes be maintained. The present bleach house was then examined to see if the increase could be handled there. The machinery was of modern type, was run at the highest practicable speeds, and could not be rearranged to provide for any additional equipment. An examination of the chemical part of the problem showed, however, that a 50 per cent increase could be taken care of with a slight increase in water and chemicals.

The problem was finally solved over protests that it had never been done before, by running two strands of cloth side by side through the same machinery at the same time instead of one as had been the previous practice. Many experiments were made before this was accomplished successfully, but the new method enabled the plant to secure approximately 50 per cent increase in production with practically the same equipment running at the same speed, with the same amount of labor and with a very slight addition of water and chemicals.

This solution caused a very considerable saving in the cost of production and also pointed the way to further investigations throughout the plant, with the result that many processes were revolutionized and large savings made.

A short time ago a mill treasurer spoke very contemptuously of the possibilities of engineering research in his plant, stating that he knew the business thoroughly, having started in it as a boy. When asked if he was not using individual "dollies" for scouring worsted cloth before dyeing, he replied that he had about twenty-five of them, each one of which required one operative. He was much surprised when informed that all of these dollies could be replaced by one continuous scouring machine, or at most two, re-

[1] Cons. Engr. and Textile Specialist.

Presented at the Annual Meeting, New York, December 5 to 9, 1921, of The American Society of Mechanical Engineers. Slightly condensed. All papers are subject to revision.

quiring but one operative each and using a smaller amount of soap. Is this not a "hidden waste?"

The increase of output in the operation of tenter frames in another plant may be taken as a further illustration. After careful engineering investigation the dry or hot room was perfected and the frames readjusted to handle the capacity of the dry room. As a result the output was increased over 150 per cent, with a 50 per cent reduction in labor cost. The saving of labor on this job alone within a few weeks more than offset the entire cost of making the study and of changes on the machines.

The foregoing examples have all been taken from dyeing and finishing plants. Turning now to an entirely different line, a knitting mill started about eighteen months ago to study its machines to see if the output could be increased. The net result of much research work on these machines together with a study of the yarn used, was that the output of the entire plant was increased more than 25 per cent with the same equipment. The number of imperfections were reduced very materially, and in spite of the higher wage rate there was a substantial reduction in the labor cost per pound of product.

VARIOUS METHODS OF CUTTING DOWN WASTE

Occasionally in the study of equipment it is found that cutting down speed may increase output as well as quality. One illustration of this may be found on pickers in a cotton-spinning mill, where a reduction in the speed of the beaters frequently raises the quality of the product, cuts down waste of materials, and betters the production in the later processes.

Considerable saving can oftentimes be made in the purchasing of materials. This requires research to determine if a cheaper product may not be used to replace a more expensive one with equal or better results. An example of this is found in the studies made to determine if a lower-grade cotton may not be utilized to advantage. The use of this cotton calls for greater care in purchasing and a careful study of the processes of cleaning and mixing to maintain proper strength and uniformity. This, however, has been done by a number of mills without lowering the quality of their product and has resulted in large savings in the finished product.

Another source of loss in many plants is due to the waste of material in process and the reworking of materials which have become damaged. Records should be kept to show the extent of these losses as such records will undoubtedly assist in reducing the waste and act as a stimulant to maintain them at a minimum. In some finishing plants, for example, the amount of rehandled goods due to stains, poor dyeing, poor bleach, etc., oftentimes reaches 15 per cent of the work done, while in other plants it falls below 1 per cent. Frequently the amounts of seconds, remnants and rags reach large figures. In some plants no records are maintained of such losses, so undoubtedly these can be characterized as "hidden wastes."

In addition to the studies in the operation of the machines and in the utilization of materials, it is desirable to standardize thoroughly the labor jobs on these machines. Frequently the engineer can develop labor-saving devices that will reduce the number of operatives required. In other cases standardization may be carried to such an extent that less skill is needed on the part of the operatives and lower-grade labor can be used.

Throughout this paper emphasis has been placed on the savings which may be made by engineering research in the textile field, which has been much neglected up to this time, and it is the belief of the author that in the future great improvements in operation will undoubtedly result by the replacing of tradition with definite knowledge of facts determined by such research.

Economy in Textile Drying

BY B. R. ANDREWS,[1] BOSTON, MASS.

THIS paper summarizes some of the means by which those expenses which contribute to the cost of textile drying may be reduced without causing simultaneous increases in damaged goods and without reduction in quality of work produced. There are many such items of expense, but they may be included under the three groups of labor, overhead, and steam.

The relative values of these groups are shown approximately in Fig. 1. The labor item includes only that labor actually applied to manufacture; the overhead item includes the labor for maintenance, as well as interest, depreciation, taxes, and the cost of power. While the relative value of each very naturally varies with the different classes of work, most textile drying is done either on cans or in an air drier, so that a fair average is obtained from a range consisting of starch mangles, drycans and tenters, and it was on such a range that the data for plotting Fig. 1 were obtained. Selection was made, not of an average installation, but of one operating with a comparatively high efficiency, thereby representing a good distribution of these expenses for low cost of drying.

It is natural to attempt drying economies by considering each item separately, yet it is no more possible to do so than in any other manufacturing process, for reduction in labor cost will probably be obtained by increase in investment and consequent overhead expense. If it is obtained by increasing the rate of drying, without much increase in investment, then a sacrifice of steam economy is likely to result. However, if the cost of handling is halved by halving the drying time, with a reasonable increase in overhead and no reduction (or even a 50 per cent increase) in steam consumption per pound of goods produced, an overall economy has resulted. Also, the increase of the rate of drying may make possible the combination into a range with calenders, starch mangles, etc., with a reduction of labor, not to one-half, but perhaps to one-third or one-fourth. Therefore, it is usually safe to assume that what is wanted above all else is to secure the maximum speed at which goods can be handled without damage, and then to maintain this speed at the minimum overhead expense and steam consumption.

While these conclusions are almost obvious, the actual drying process itself is not quite so clear, and a general understanding of it is necessary in order to consider this item of speed intelligently. Textile drying is usually nothing more than the conversion from liquid to gas of the free water, or free solution, carried by the material after leaving the extractor, suction box, or squeeze rolls. The hygroscopic moisture enters only rarely into the problem; that is, the process is really "drying," and not the processing often

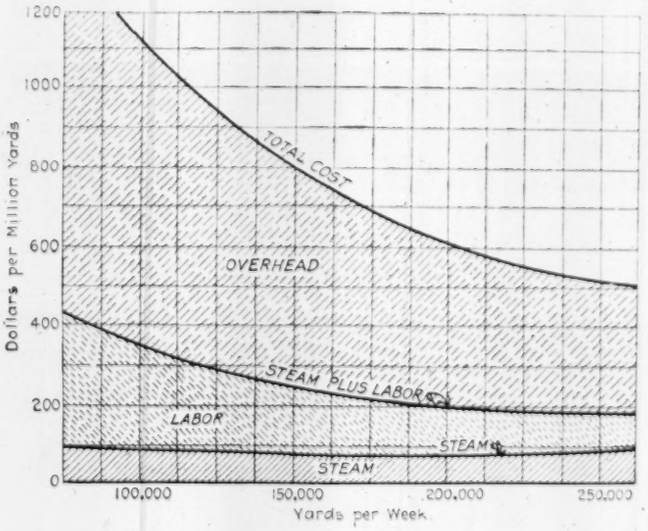

FIG. 1 COST OF DRYING AFTER STARCHING.—5-YD. GOODS

[1] Treas., Andrews & Goodrich, Inc.

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erroneously called "drying," which must be carried on under the most carefully regulated combinations of temperature, humidity and time. Consequently, with drier temperatures not exceeding 220 deg. fahr. and humidities approximating bone-dry atmosphere, we have simply a matching of vapor tension between the water in the material and the air in immediate contact with it. The higher the former, and the lower the latter, the more rapidly the process can be carried on.

There are three good ways of raising the vapor tension of the water in the material: (*a*) by contact with a hot surface; (*b*) by contact with hot air having a high wet-bulb temperature; and (*c*) by radiant heat.

There are two good ways of maintaining a low humidity in the air in immediate contact with the material: (*a*) by a high drier temperature; and (*b*) by rapid air circulation. The second is of the utmost importance because the film of air in immediate contact with the surface in an undisturbed atmosphere becomes very nearly saturated.

In the case of a material brought into contact with the hot surface, moisture may be transferred immediately into water vapor by maintaining the temperature of this surface high enough to keep the water in the material above 212 deg., the vapor then condensing and being reëvaporated by the surrounding atmosphere. It is just this method of drying that is utilized with drycans and drum slashers. It gives the most rapid rate of drying, as well as the greatest economy, particularly where an air current is used to disturb the sluggish film of saturated vapor on the surface of the material, thus giving a direct evaporation in addition. Such air circulation is best obtained by properly designed hoods over the slasher and blast nozzles on drycans.

In case of a material which cannot be brought into contact with the hot surface, but which must be dried quickly, rapid air currents become almost absolutely necessary and radiant heat desirable. However, the use of air currents and radiant heat is usually limited by the nature of the material and its possible arrangement in the drier, so that the most common form of textile drying, next to drycans and slashers, is that in which the material is heated and the latent heat of evaporation entirely supplied by the air in contact with it. For example, skein driers and festoon driers, with which the air is blown over or around the product, stock driers, and the "mast" type of knit-goods driers, with which the air is blown through the stock. However, there are cases in which strong air blasts and radiant heat can both be used, such as with a straight-away tenter frame. Here radiant heat alone, plus the convection, which is a natural result, will give one rate of drying; air blasting alone at a high temperature will give a higher rate; but a combination of the two, the highest rate.

From the foregoing it will be seen that textile drying resolves itself into two general classes: (*a*) with the material in contact with a hot surface; and (*b*) with the material in contact with air only, so that for a study of steam economy it is best that the two classes be considered separately; and the following table, prepared from the averages of many tests run on efficient drycans without air blast, gives the approximate distribution in per cent of the total steam used for the evaporation of one pound of water:

	Per Cent
Loss by radiation	20
Heating wet material	1
Evaporation of water	79
Total	100

or 1225 B.t.u. or 1¼ lb. steam at 5 lb. gage.

That drying on cans is a very efficient method is apparent and well known. However, actual mill averages often run double this consumption because of time lost between runs and improper proportion of width of goods to the width of cans.

In the second class of driers, possible economy of steam is much greater, for while the steam used per pound of water evaporated in a practical air drier can never be equal to that used in contact driers, the average air drier is more complicated and therefore more difficult to build and operate efficiently. The following table gives the destinations of heat required to evaporate one pound of water as calculated from test data on such a drier of more than average efficiency:

	Per Cent
Loss by radiation	14
Heating wet goods	0.5
Evaporation of water	46.5
Air change	39
Total	100

or 2150 B.t.u. or 2¼ lb. steam.

No loss has been attributed to leakage, because a properly designed drier can usually be so arranged that even though it may not be made air-tight, and openings must be provided for ingress and egress of the material, all of the leakage can be inward and become the new air required for evaporation without upsetting to any great degree the most efficient route of air travel through the drier.

Inasmuch as neither the heat required for evaporation, nor that necessary to raise the wet material to the temperature at which evaporation takes place, can be reduced to any material extent, steam economy must be effected by a reduction of radiation loss and the heat required to raise the temperature of the new air used to carry off the water vapor. It is sometimes possible to use the heat contained in this exhausted air either for heating or to augment some other drying process where a high percentage of humidity is permissible or desirable.

In the foregoing brief statement of generally well known drying facts, it has been the intention to bring out

1 The desirability of reducing the drying time in any drier at the expense of steam, or even labor, because of the preponderance of the overhead item

2 That this increase in the rate of drying must usually be obtained by increased temperature of the material being dried, and decreased vapor tension of the air actually in contact with it

3 That reduced labor costs, while usually a natural consequence of increased speed from the drier, can often be further reduced by combining the drier with other machinery into a range

4 That steam consumption can be cut only by eliminating leakage, reducing radiation by insulation, and using the minimum amount of new air for removal of water

5 Because cans meet all these conditions, they should be used in preference to all other types of driers wherever the nature of the product will permit.

DISCUSSION AT THE SESSION ON TEXTILE WASTE

AT THE session on Textile Waste, Past-President Charles T. Main, who had been appointed, with Sidney B. Payne, to represent the Society at the Second World Cotton Conference, held in June, 1921, in Manchester, England, submitted his report. Two papers were also read, namely, Hidden Wastes in Textile Plants, by Thayer P. Gates, and Economy in Textile Drying, by B. R. Andrews.

The discussion of the paper by Mr. Gates was opened by Clarence W. Marsh[1] who spoke of the possibilities of textile plants making some of the materials used by them. It is a fact, he said, that any concern using chlorine and caustic soda, especially a textile mill where steam is used for heating and power is therefore comparatively cheap, can make it infinitely cheaper than it can be bought. The reason, he said, is that many of the steps necessary to convert chlorine bleach into the finished product which the textile manufacturer uses represent economic waste. Chlorine and caustic soda can be used as delivered from the mill without conversion. To liquefy chlorine, he said, costs a cent and a half, the container from half a cent to a cent, and shipping a cent and a half. Money must be spent on the control apparatus for the liquid chlorine when an equal amount might purchase apparatus for making chlorine. And finally, the liquid chlorine must be transformed again into a gas.

Francis A. Chiffelle[2] said he wanted to emphasize the need of plant investigation. He asked if there was not a limit to the speed of tenters. A tenter chain, he said, was not built for high speed. Chain manufacturers would hesitate about putting in a chain like a tenter chain on ten-tooth sprockets and yet all tenter chain is run

[1] New York, N. Y.

[2] Ch. Engr., Slatersville Finishing Co., Slatersville, R. I. Mem.Am.Soc. M.E.

on ten-tooth sprockets. With expensive chain like tenter chain there is a limit to the speed which should be allowed. Chain manufacturers, he said, figure on about 350 ft. or 116 yards per minute. The author said he had known tenter chains which had been running two years at a speed of 110 yards per minute, and occasionally at a maximum of 140 yards per minute. Mr. Chiffelle thought that this speed was too great for economy, and the author replied that the problem was to determine whether it was cheaper to run fast and have the chain wear out in a few years, or to run slow and have it last twenty.

D. M. Bates[3] spoke of his experience in replacing the iron bearings of chains with maple, and of work done by the late H. L. Gantt in doubling the yardage in textile plant with less wear and tear on the machinery. In regard to textile mills making their own bleach, as had been suggested by Mr. Marsh, he pointed out that this had been considered many times. The convenience of handling the liquid chlorine was appealing, even though the liquid was expensive. There were also difficulties, he said, in making chlorine in the relatively small quantities required by the average cotton bleachery.

H. M. Burke[4] said that as an engineer he realized that more scientific knowledge of the textile industry was needed. It was hard, he said, to convince owners of textile plants that this was so. Much of the knowledge of methods and machinery, however, was merely empirical. There was, he thought, a need for research in this field. It might be necessary to get enough publicity from engineers to sell such ideas to the man handling the money in a textile plant. This could not be done properly unless the processes were studied scientifically.

The author said that it had been his experience that it was easier to convince the man who handles the money than a board of directors. He had found it a good plan to tackle one problem at a time and to get results. Results were always pleasing to the board of directors.

Mr. Burke compared the textile with the shoe industry, in which highly specialized machinery had been introduced as a result of study.

Paul A. Marion[5] opened the discussion of Mr. Andrews' paper on Economy in Textile Drying. The author, he said, had pointed out very clearly that the way to increase economy in textile drying was to increase capacity. Several means of increasing capacity had occurred to him. The most important factor was the operator. Many existing installations would be capable of greater capacity if operators could be induced to obtain it. A second means was to improve the load factor in the case of multiple-width cans; to load these cans to the proper width with the number of strands for which they were designed. Why should finishing plants not be run twenty-four hours a day like paper mills? Another means of increasing capacity, he said, was to put all machinery in first-class condition, and another by removing the moist air from the cloth.

L. B. McMillan[6] discussed some statements by the author which had to do with loss of heat from galvanized iron surfaces. He pointed out that the tests made at the University of Illinois which showed that more heat was lost from such surfaces when covered with asbestos paper and to which the author referred, were correct, but he was afraid that a wrong interpretation might be placed upon the results because of the fact that the radiation from bright polished surfaces of galvanized iron or tin would increase as the surface became dulled by rust.

He also spoke of the insulating value of air spaces, pointing out that in order to be effective these spaces must be extremely small so as to prevent a circulation of air within them.

The author replied that he did not wish anything he had said to be taken as a complaint against asbestos insulation on the surfaces he had referred to. It was interesting to note, however, that these surfaces in connection with driers did stay bright.

J. A. Campbell[7] asked if double ends were still used on driers to take off the large amount of moisture that comes from nozzles on straightaway tenters. The author replied that he had not seen such installations in the last few years.

Charles H. Bigelow[8] asked what differences were found in applying air on the top and on the bottom of goods in straightaway tenters where a source of hot air is used. The author replied that such differences would depend upon the arrangement of the heater. It seems to make no difference if only air is used whether it is blown on the top or the bottom but with heater coils located above the goods there is always a danger of spots from dust and water dropping from above.

W. H. Carrier[9] said he wished to commend the author's consideration of the economic as well as the engineering features of drying. In the interest of accuracy he wished to clear up a possible ambiguity in the sixth paragraph of the author's paper where he states: "There are two ways of maintaining a low vapor pressure in the air in immediate contact with the material." All investigations show, he said, that the air in immediate contact with the material is saturated. The degree of saturation cannot be lowered. The saturated air can be removed, and by raising the temperature the moisture content of the air is raised. Heating has the effect of removing more moisture for the reason that the film of air near the surface of the material can absorb a greater amount of moisture for a given mass. The vapor pressure is increased, not decreased, and this involves a more rapid rate of drying. The object stated by the author is accomplished, but in the opposite way. A higher drier temperature does not decrease the vapor pressure of the air which is fixed by the air supply and depends on the dewpoint. It does raise the wet-bulb temperature and the vapor pressure of the moisture. The vapor pressure of the air in the film in contact with the material depends on the wet bulb-temperature. The rate of evaporation depends on the difference of vapor pressure of the film of air and the vapor pressure of the surrounding air. The vapor pressure of the film is above the vapor pressure of the air, and the higher temperature causes a high vapor-pressure difference. Rapid air circulation does not lower the vapor pressure on the material, except in the case of dryeans and paper machines. The ambiguity lies in the fact that the type is not specified. If the author refers to dryeans and paper machines, his statement is true and applies, but if air alone is used it does not apply, for in this case the vapor pressure of the air is not lowered, but remains practically constant and depends on the wet-bulb temperature. The effect of high velocity, however, is very important, as the author points out, because at high velocities the film of saturated air in contact with the material is swept away. For example, if the velocity is increased from that of still air to 230 ft. per min., the evaporation is doubled, and if to 280 ft. per minute, it is trebled.

De-Ironing Water

The water from the Metropolitan Water Board's wells at Waltham Abbey and Rammey Marsh having become charged with iron, it was decided to lay down a plant to deal with the trouble. The work is now nearing completion. The plant installed consists of twelve Candy iron-removing filters, each of 8 ft., 3 in. internal diameter and about 7 ft. high. The filtering medium consists of aerating and iron-removing sand and polarite. A small quantity of compressed air will be injected into the unfiltered water for the oxidazation of the iron in solution. The polarite acts as a catalytic agent, transferring the dissolved air to the iron with which it combines to form an insoluable hydrated oxide of iron. By this means it is hoped to reduce any iron which may be contained in the water to be treated to 0.01 part per 100,000. Ten of the filters, which will together be capable of treating two million gallons of the water in twenty-four hours, will usually be in service together, the remaining two acting as spares. For working the filters, a compressor plant, driven by Pelton wheels, has been installed. The whole of the apparatus is enclosed within a brick building, having a reinforced-concrete roof. The subsoil on which the building had to be erected is of a peaty nature, and is charged with water. It was consequently necessary to support the filters and the building on a reinforced-concrete foundation supported on reinforced-concrete piles.

[3] Vice-Pres., Day & Zimmermann, Inc., Philadelph'a, Pa. Mem.Am. Soc.M.E.

[4] Mech. Engr., Mt. Hope Finishing Co., N. Dighton, Mass. Mem.Am. M.E.

[5] 389 Charles St., Providence, R. I.

[6] Cons. Engr., H. W. Johns-Manville Co., New York, N. Y. Assoc-Mem. Am.Soc.M.E.

[7] Mech. Supt., D. Goff & Sons, Pawtucket, R. I. Mem.Am.Soc.M.E.

[8] Ch. Mech. Engr., Millville Mfg. Co., Millville, N. J. Mem.Am.Soc. M.E.

[9] Pres., Carrier Engrg. Corp., New York, N. Y. Mem.Am.Soc.M.E.

Significance of Standardization to American Industry and the Federal Government

The Advantages of Standardization to All, Including the Government as the Largest Consumer—How the Government Should Coöperate with Industry—What is Being Done by the American Engineering Standards Committee

By A. A. STEVENSON,[1] PHILADELPHIA, PA.

THE significance and importance of standardization to industry and to the Federal Government seem almost axiomatic to those of us who have been actively interested in standardization work for a number of years, and since the present is a particularly opportune time for the launching of extensive coöperation between Government and industry, it seems well to point out the opportunities and means for such coöperation in industrial standardization.

The United States Government is probably the largest purchaser of materials in the world. The War and Navy Departments obviously have special requirements with reference to their military needs, but aside from these the interest of the Government in standardization is the same as that of all other consumers. The Government maintains an unrivaled group of research organizations, the principal object of which is the furthering of the development of our industries. In addition, the efforts of the present administration show a keen appreciation of the importance of standardization and its bearing upon industry as a whole, and constitute a most significant development in the relation of the Government and industry.

Of the many advantages to be derived by both industry and the Government from standardization along national lines, the most important seem to be:

1 Mass production, with its obvious advantage to the producer, means reduction in cost. Competition engendered by such production insures to the consumer, including the Government, the benefit of reduction in price.

2 Elimination of wide varieties and sizes permits producers to concentrate on those retained, and facilitates improvements in method and equipment that will ultimately result in the elimination of waste and the reduction of cost to the consumer, including the Government.

3 Putting all tenders on an easily comparable basis, promotes fairness in competition in both domestic and foreign trade, to the benefit of both producer and consumer.

4 Elimination of indecision in both production and utilization removes a prolific cause of inefficiency and waste.

5 Stabilization of production and employment means for the producer uninterrupted manufacture from stock during periods of depression. This is of vital interest to the Government as being of benefit to the country as a whole.

6 Accumulation of stock means prompt deliveries by the producer, and eliminates the necessity of the Government itself carrying a large inventory of material.

Again, the World War showed us the need of standardization along national lines, and the results obtained were of unlimited service to the country as a whole. Would it not be a calamity not to profit by the lessons taught by these experiences, adapting them to peace-time conditions? The advantages of national standardization are no less real in the midst of the post-war readjustment struggle. The need for unification of standards is, in fact, greater than ever before; for the manufacturer needs it to obtain maximum production, the distributor to minimize stock carried, and the consumer to secure articles at the least possible cost.

Standardization as a Factor in Trade

In outlining some of the factors tending to emphasize the significance of standardization, the great importance of standardization in helping to retain our foreign trade and meet keen competition from abroad has not been mentioned. In both Great Britain and Germany, national standardization is being carried on intensively. German industries are carrying out a far-reaching program of standardization as a necessary step in building up an unprecedented industrial structure which must rest in large measure on an extensive foreign trade. It is being woven very intimately into the industrial fabric of the country under the guidance of an organization which functions very much like the American Engineering Standards Committee, and in its work 5000 German industrial firms are coöperating.

Coöperation Between Government and Industry is Vital

For reasons for which neither can be blamed exclusively, there is no doubt that the industries of this country and the Government Departments in many instances have not coöperated in a way to insure best results in standardization along national lines.

In national standardization the coöperation of the Government is necessary to industry and vice-versa. This result can best be realized through representative conferences in which specific projects are initiated, and representative committees by which the work on specific projects is carried out. In the work of such conferences and committees, industry and government should participate actively through accredited representatives of all interested bodies. It has been the experience of the American Engineering Standards Committee that the necessary industry-wide spirit of coöperation is developed and utilized through such representative conferences and committees. No doubt this statement would find confirmation in the experience of the Government Departments which have followed the same comprehensive plan.

To obtain the maximum of benefit from coöperation with industry, the Government should not attempt to set up standards at variance with standards acceptable for use by others for identical purposes. It should consider itself one (although a very large one) of the many consumers, and in its dealings with the manufacturers should coöperate with other consumers in formulating standards acceptable to both producer and consumer.

By means of conferences and committees truly representative of each industry as a whole (including consumers as well as producers), the bureaus can determine what are the needs of industry and learn in just what way their facilities can best be utilized. The bureaus need have no fear that their services will not be appreciated. The fact is that they will be recognized as being indispensable to the industries, and the industries will use their powerful influence to insure for the bureaus adequate equipment and personnel to carry on their work in a proper manner.

Benefit of One Set of Standards for All

The benefit to be derived from having only one set of standards is so great that the producers should be willing to comply with more severe requirements that are uniform, in preference to less severe requirements different for each consumer or group of consumers. On the other hand, consumers should be willing to accept less severe requirements, thereby obtaining the benefit derived from economy in manufacture, rather than insisting on more severe requirements with accompanying added cost. An ideal specification is one which can readily be met by a producer who is competent and willing. When a specification is so severe that it condemns much good material, it results in economic waste. The creation of uniform national standards means economy for the producer, the consumer, and the country as a whole, and hence activities which will accomplish this desired result should be encouraged by the Government to the maximum extent.

[1] Chairman, 1921, American Engineering Standards Committee. Mem. Am.Soc.M.E.

Abstract of paper presented before the Washington, D. C. Section of The American Society of Mechanical Engineers, December 9, 1921.

A recent event of unusual importance was the organization of the Federal Specifications Board, for unifying the specifications for all Government purchases, military as well as non-military. This Board has been charged with the duty of compiling and adopting standard specifications for materials and services, and bringing specifications into harmony with the best commercial practice wherever conditions permit, in order to broaden the field of supply. If common standards are arrived at for the Government and the industries of the country, might it not be advantageous to have a common agency charged with the duty of determining what materials and services do meet properly the standards adopted? It is understood that in at least two of the most important industries of the country plans are now under consideration for the establishment of such a common bureau of inspection. As illustrating the possibilities of such a plan, may be mentioned the great services rendered both the industries and the Government by the adoption of uniform specifications for electric lamps, and the concentration of the inspection of all Government specifications for such lamps.

In discussing the relation of the Federal Government to the movement for industrial standardization along national lines, one naturally thinks first of the Government as a great consumer. But the relation is far broader than that, for in lending its moral and material support to the movement, the Government has an opportunity of the first importance in its labors to "promote the general welfare" of the country as a whole.

Relation of Government Research to Standardization

The relation of the great Federal research bureaus to industrial standardization is no less important than that of the great purchasing bureaus. Research and standardization are very closely related, and in many ways they are supplementary. By showing the need of reliable information as to the facts, in order to determine the best practice, and secure agreements on moot questions, standardization acts as a powerful stimulus to research and development. But what is of even greater importance, standardization is a principal means of getting the results of research and development work into actual use in the industries, so that the industries themselves, and finally the general public, may reap the advantages.

One of the most direct and effective methods of getting the results of the investigational work of the research bureaus introduced into, and of service to the industries, is by coöperation between the research bureaus and the industries, through working standardization committees, which must necessarily be joint committees of the various bodies interested in each specific project. The many advantages of such coöperation, both to the industries and to the bureaus, are obvious.

What is no less important, such coöperation is very effective in helping to extend a knowledge and appreciation of the work of the bureau in the associations speaking for the industry. As illustrating the significance of this, considerably more than a hundred national organizations are now coöperating through accredited representatives in the work of standardizing committees functioning under the auspices and rules of procedure of the American Engineering Standards Committee. In this work the Bureau of Standards, the Bureau of Mines, and the Forest Service are taking a very active part, and in so doing are rendering extremely important services to their respective industries. This coöperative work will be no less valuable to these bureaus than it is to industry.

Clearing House for Standardization Essential

In order that standardization along national lines may be brought about, it is necessary that there be some central body to act as a clearing house in standardization work. It is essential that there be brought together information concerning the organizations by which standards have been formulated and are being promulgated and details relating to such standards as are already in use. From the central body charged with the duty of collecting this information, it should be transmitted promptly wherever needed to insure the elimination of conflicts in the formulation of standards. The success to be expected from a central body organized for the purposes just stated obviously depends upon the authority invested in it, and the recognition received by it from the organizations throughout the country which are engaged in doing standardization work.

The need for closer coöperation in order to prevent duplication and the promulgation of conflicting standards in America crystallized in the appointment of a committee by the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Society for Testing Materials, which formulated a plan resulting in the organization of a permanent committee made up of representatives of the five societies mentioned and the three Government Departments of War, Navy and Commerce. The Constitution of this committee, the American Engineering Standards Committee, was broadened later to permit the representation of other bodies, and at the present time it has 50 representatives from 18 bodies or groups of bodies including 7 national engineering societies, 13 national industrial associations, and 5 Government Departments, including the Departments of Agriculture and Interior in addition to the three already mentioned. There are now 37 different national organizations which have accepted sponsorship for a total of 59 projects. In addition there are 108 coöperating organizations other than the sponsor bodies, bringing the total to 145 national organizations who are actively coöperating in the work of the American Engineering Standards Committee and who have appointed accredited representatives to serve on sectional committees.

Objects of American Engineering Standards Committee

The objects of the American Engineering Standards Committee briefly stated are:

"To unify methods of arriving at engineering standards, and to secure coöperation between various interested organizations, in order to prevent duplication of work and promulgation of conflicting standards.

"To receive and pass upon recommendations for standards but not to initiate or develop the details of any particular standard.

"To act as an authoritative channel of coöperation in international engineering standardization.

"To promote in foreign countries the knowledge of recognized American Standards.

"To collect and classify data on standards and standardization bodies in the United States and foreign countries, and to act as a bureau of information regarding standardization."

As a result of the work in which the American Engineering Standards Committee is now actively engaged, existing conflicting standards are being brought into harmony, and there are being created truly representative committees to formulate new standards. The methods employed obviously differ somewhat from methods utilized hitherto, and it must be acknowledged that they are not yet fully understood by many of the organizations in America that should be coöperating in standardization along national lines.

The Rules of Procedure of the American Engineering Standards Committee are at times misunderstood, not by reason of their complexity but because of their extreme simplicity. Only when a standard has been formulated under such auspices that it has the endorsement of substantially the whole of the industry to which it applies is it considered qualified to be designated an "American Standard." The advantage resulting from insuring that all standards to be thus designated have been formulated under the proper auspices and are acceptable to the industry involved are so self-evident that it is sometimes difficult to understand why everyone does not appreciate the industrial significance of the work of the American Engineering Standards Committee. The Committee does not concern itself with the technical details of the standards submitted to it for approval, or formulated by committees organized under its auspices, but limits its investigations to a study of the procedure followed in developing the standard with particular reference to the representative character of the group of persons by which the standard has been formulated and the organizations by which it has been adopted or approved.

The decision of the American Engineering Standards Committee

(Continued on page 203)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Thermodynamic Bases for Determining Efficiency to be Expected from Gas Turbines

By H. SCHMOLKE

TESTS resumed since 1918 with 8000-hp. Holzwarth gas turbines justify the expectation that the difficulties of applying gas turbines for driving turbo-dynamos are not insuperable. The internal-combustion engine may in the not distant future reach a stage of development to a position to compete with the prime movers now employed in electric central stations. In fact, the German State Railroad Administration has already placed orders for several Holzwarth turbines of considerable capacity, and the experience of operating them ought to aid in their further development.

Whether the final aim will ever be attained, depends of course in the first instance on the efficiency to be attained in this type of apparatus. If for one reason or another it is basically impossible to attain a degree of efficiency that will place the gas turbine on a par with other types of heat engines, obviously all the efforts of Holzwarth and other investigators in the field are doomed to failure. Hence it is of the greatest importance to determine in advance the maximum efficiency to be expected from a projected installation, and the following represents a kind of synopsis of investigations published within the last 10 years by prominent experts in thermodynamics. In this connection the gas-entropy chart is of paramount importance. Such a chart may be obtained by plotting curves of equal pressures and equal volumes, with ordinates representing the absolute temperature T and abscissæ the entropy S. The curves themselves may be derived by the following process of calculation.

It is a well-known fact that the heat supplied during the process is equal to

$$dQ = TdS = c_v dT + Ap dv$$

when c_v is the specific heat at constant volume, A the heat equivalent, p the specific pressure and v the volume. From this it follows that

$$dS = c_v \frac{dT}{T} + Ap \frac{dv}{T}$$

It is, however, possible to write

$$T = \frac{pv}{R}$$

in accordance with the equation of state, provided R is a gas constant. If this relation be introduced into the second term of the right-hand side of the equation, we obtain

$$dS = c_v \frac{dT}{T} + AR \frac{dv}{v}$$

and this after integration between the initial values of T_0, v_0 and the final values T, and v gives

$$S - S_0 = c_v \log \frac{T}{T_0} + AR \log \frac{v}{v_0}$$

or, with common logarithms,

$$S - S_0 = 2.303 \left(c_v \log \frac{T}{T_0} + AR \log \frac{v}{v_0} \right)$$

There are, however, the two well-known thermodynamic equations:

$$pv = RT \text{ and } c_p = c_v + AR$$

from which and the preceding equation, it follows that

$$S - S_0 = 2.303 \left(c_p \log \frac{v}{v_0} + c_v \log \frac{p}{p_0} \right)$$

but at constant pressure $p = p_0$ and $\log \frac{p}{p_0} = 0$.

This gives for the desired curve of pressure the formula

$$S - S_0 = 2.303\, c_p \log \frac{v}{v_0}$$

Since, further, in accordance with the equation of state with pressure p constant, T/T_0 is v/v_0, one easily obtains for the curve the very convenient expression $S - S_0 = 2.303\, c_p \log \frac{T}{T_0}$. If, on the other hand, it is the volume that is constant, that is, $v = v_0$ and $\log \frac{v}{v_0} = 0$, we obtain in a similar manner the expression $S - S_0 = 2.303\, c_v \log \frac{p}{p_0}$, and as at constant volume one may write $p/p_0 = T/T_0$, the above equation may be written as

$$S - S_0 = 2.303\, c_v \log \frac{T}{T_0}$$

Now, if the entropy of a gas at 0 deg. and any pressure p_0 as well as volume v_0 be stated as being equal to 0, it becomes possible to plot either the pressure or volume curve on the T-S diagram. In order, however, to plot the curve of pressures for a higher pressure, it is necessary to determine its origin on the ordinates. To do this, it is necessary to compute the temperature in adiabatic pressure from p_0 to np_0, where n may be any number. According to the equation of state

$$\frac{T_2}{T_1} = \frac{p_2 v_2}{p_1 v_1}$$

and further in adiabatic compression

$$p_1 v_1^{\kappa} = p_2 v_2^{\kappa} \text{ or } \frac{p_2}{p_1} = \left(\frac{v_1}{v_2} \right)^{\kappa}$$

By combining this equation with the preceding one, we find

$$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2} \right)^{\kappa - 1}$$

and furthermore, since according to the adiabatic equation

$$\frac{v_2}{v_1} = \left(\frac{p_1}{p_2} \right)^{\frac{1}{\kappa}}$$

we find that

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1} \right)^{\frac{\kappa - 1}{\kappa}}$$

If we write now $p_1 = p_0$ and $p_2 = np_0$, we arrive at equation

$$\frac{T_n}{T_0} = \left(\frac{np}{p_0} \right)^{\frac{\kappa - 1}{\kappa}} = n^{\frac{\kappa - 1}{\kappa}}$$

This equation determines also the origin of the line of pressures for the compression n times as great. Where the curve of volumes in adiabatic compression begins at the nth part of the original volume, the equation

$$\frac{T_2}{T_1} = \frac{T_n}{T_0} = \left(\frac{v_0}{\frac{1}{n} v_0} \right)^{\kappa - 1} = n_{\kappa}^{-1}$$

holds good. With these two equations available there is nothing further needed in laying out the entropy charts.

Prof. A. Stodola, of Zurich, Switzerland, was probably the first to plot such curves. In the fourth edition of his work on Steam Turbines he published a temperature-entropy diagram for gases, diagrammatically reproduced on the right-hand side of Fig. 1. In developing the arithmetical foundations for the computation of these curves, the specific heat at constant volume c_v of the gases under consideration was referred to the mol, which was indicated by the use of a modified script. It was assumed that $c_v = a + bT$, where $a = 4.67$, and b is a constant depending on the properties of a given gas. It was expected that in this way the variation of heat capacity with temperature would be sufficiently taken care of. Under this assumption it would be found from the above equation

$$dS = c_v \frac{dT}{T} + AR \frac{dv}{v}$$

that

$$d\mathfrak{S} = a \frac{dT}{T} + b dT + A\mathfrak{R} \frac{d\mathfrak{V}}{\mathfrak{V}}$$

the bold-face letters indicating that the quantities are computed on the mol basis. From this, by integration between definite limits, it is found that

$$\mathfrak{S} - \mathfrak{S}_0 = a \log \frac{T}{T_0} + b(T - T_0) + A\mathfrak{R} \log \frac{\mathfrak{V}}{\mathfrak{V}_0}.$$

The variation of entropy is therefore expressed by a sum of three members which are plotted on the diagram from an inclined ordinate. The inclination of the line parallel to OX to the line parallel to OY varies with the value of b, while the chart to the right of the above-named line remains the same for all gases, due to the fact that all values are calculated on the basis of a mol, and therefore $\mathfrak{R}$ as well as a has the same value for all gases. The suction area located under the line AB is the amount of heat $\mathfrak{W}_v$ which must be supplied to one mol in order to increase at constant volume the temperature from T_0 to T. In order to express this amount of heat in terms of area, the values of $\mathfrak{W}_v$ are plotted as abscissæ to the right of point O on the vertical line, these values being

$$\mathfrak{W}_v = \int_{T_0}^{T} C_v dT = \int_{T_0}^{T} (a + bT)\, dT = (aT + \frac{b}{2} T^2) - (aT_0 + \frac{b}{2} T_0^2)$$
$$= \mathfrak{W}_b - \mathfrak{W}_a.$$

By repeating this process for various temperatures, one obtains the parabolic curve known as the heat curve. To the left of O the magnitudes $A\mathfrak{R}T$ appear as abscissæ.

At constant pressure the number of calories, which on the right-hand side of the diagram in Fig. 1 is represented by the enclosed area under curve AC, is equal to

$$\int_{T_0}^{T} C_p dT = \int_{T_0}^{T} (C_v + A\mathfrak{R})\, dT = \mathfrak{W}_v + A\mathfrak{R}(T - T_0) = \mathfrak{W}_c - \mathfrak{W}_{ap}$$

The spaces limited by the vertical lines at O and the line $A\mathfrak{R}T$ are therefore the differences between the amounts of heat at equal pressure $\mathfrak{W}_p$ and at equal volume $\mathfrak{W}_v$, which permits the careful determination of these two magnitudes.

Prof. P. Ostertag, of Winterthur, Switzerland, from whose writings the above scheme has been borrowed, uses the Stodola entropy diagram in a similar manner for the calculation of gas engines of all kinds. With all due respect to his work, however, it should be mentioned that the assumptions lying at the foundation of the above diagram are by no means universally satisfactory. In particular, the assumptions with respect to the specific heats are by no means free from objection. As has already been mentioned, it has been here assumed that $c_v = 4.67 + bT$. Here b for the simple gases H_2, N_2, O_2 and CO is equal to 0.00106, for CO_2 0.00568 and for superheated steam 0.00421; but such a manner of representing the function relation between heat capacity and temperature, while perhaps not objectionable for the first group of gases, is entirely insufficient for H_2O and CO_2. The specific heats of these subtances are very far from following the simple straight-line law, as has long ago been clearly demonstrated with regard to steam by the researches of Jakob, Knoblauch, Winkhaus and others.

It was therefore an important step in advance when, by carefully considering the available experimental data, Prof. W. Schuele, of Goerlitz, developed a diagram in which were shown the heats which must be supplied at constant pressure or volume to 1 cu.m. of air from 0 to 760 mm. in order to produce either a rise or fall of temperature. These heat values are computed in the following manner: If the temperature rises, for example from 0 deg. cent. to t deg. cent., the calories consumed at constant pressure $= \frac{m(c_{pm}) \times t}{22.4}$, where c_{pm} is the average specific heat in the respective region of temperature referred to 1 kg. of subtance and m is the molecular weight. Hence, $m(c_{pm})$ is the average molecular heat, and from this by the law of Avogadro the specific heat per cubic meter of substance may be obtained by dividing the above expression by 22.4. If the rise of temperature occurs at constant volume instead of constant pressure, as above, then the member c_{pm} is replaced by c_{vm}. In the Schuele diagram the heat values at constant pressure obtained in the above manner are shown as ordinates

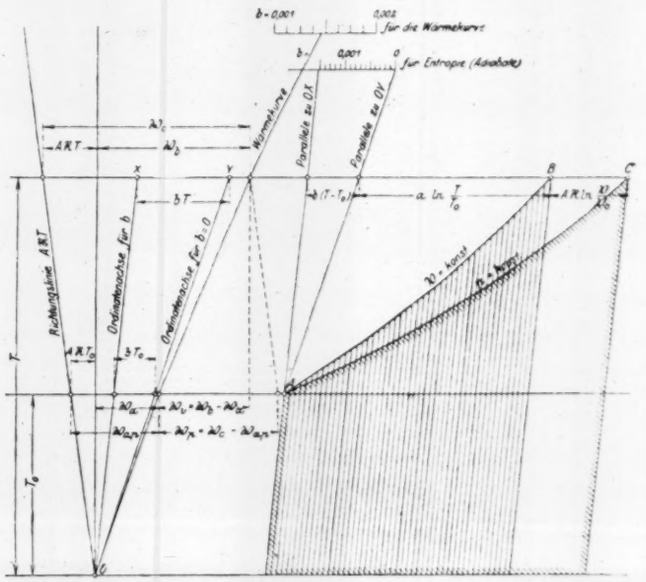


FIG. 1 STODOLA'S GAS ENTROPY DIAGRAM

(*Richtungslinie* = line; *Ordinatenachse fuer* = axis of ordinates for; *Waermekurve* = curve of heats; *Parallele zu* = parallel to; *fuer die Waermekurve* = scale for the curve of heats; *konst.* = constant; *fuer* = for.)

over temperature as abscissæ. Side by side with the curve for air is plotted another curve giving the same kind of values for pure "fire gas," i.e., the products of combustion generated when there is no excess of air. Between the air and gas line there are several broken-line curves representing more or less diluted "fire gas." The heat values at constant volume are

$$\frac{A\mathfrak{R}T}{22.4} = \frac{1.985\, t}{22.4}$$

less than the values at constant pressure. The new diagram replaces to a certain extent the left-hand portion of the entropy diagram of Stodola. Furthermore, it contains material which graphically represents the average molecular heats and the relation $\kappa = \frac{c_p}{c_v}$ for air as well as for the pure and diluted "fire gas." Schuele modified the right-hand part of the Stodola entropy diagram, which was the heat diagram proper, by plotting on the rectangular system of coördinates the p and v curves. While, strictly speaking, this diagram holds only for simple gases, it may be applied also to the products of combustion, provided only that one may assume there is present in them a material excess of air with only a slight content of steam. Thus, for example, there is no difficulty in representing graphically by means of the diagrams the processes that occur in the Holzwarth gas turbine.

The curves obtained in this way become quite understandable if one takes into consideration in connection with them the pressure diagram of such a machine as is shown in Fig. 2, which, together with

Fig. 4, is taken from the second volume of Schuele's Thermodynamics which appeared in 1920. In the Holzwarth turbine the precompressed gas-air mixture is ignited in a separate chamber, and as a result of the explosion there occurs an increase of pressure at constant volume (AB). Then a valve opens and provides access to the turbine wheels, which the gas jet reaches after an expansion in a nozzle. If one should assume now that this expansion together with the pressure rise through combustion occur without any exchange of heat taking place, the expansion curve BC is an adiabatic. The gain in work through expansion is represented by the area BCE. Since back of the turbine there is a partial vacuum, C lies below the atmospheric line. There occurs a removal of the exhausted gases by suction which is represented by the line CE. If the exhaust gases have reached a temperature corresponding to the point G the air must first be brought down to a pressure of 1 atmos., and then the new gas-air mixture must be brought to the pressure GA which exists at the beginning of the explosion. The work of compression required for the above processes is represented by the area $AGDp_0$. It is now easy to understand the entropy diagram of Fig. 4. The explosion occurs at the point A'. The increase of pressure resulting therefrom is represented by the line of equal volumes $A'B'$. The area $A'B'B''A''$ corresponds to the total heat supplied as a result of the ignition of the mixture. The temperature of the point B' is found by reading from the heat-capacity-temperature diagram the amount of heating produced by the supply of heat generated by the explosion. The adiabatic of expansion is $B'C'$. The curve joining it indicates the partial pressure of the gas. The total gain in work is $B'C'E'$. The point E' is found in the same way as in the p-v diagram of Fig. 2—namely, by prolonging the iso-volume line $A'B'$ past A' until the intersection of the curve of pressures C'. When G' is reached compression begins and the work employed therefore is represented by the area under $G'A'$. It is delivered by a steam turbine driven by heat derived from the exhaust gases of the gas turbine. If the contents of the combustion chamber of the gas turbine were subjected to no precompression before explosion, they would have had, instead of the p curve through C', the line $C_1'A'$. The area $A'B'C_1'$, which now represents the gain of work, has decreased in size quite considerably, while the total heat supply has not changed. Therefore there has occurred a reduction in efficiency. If the back pressure has become smaller than in the previously considered case, it will be seen that the curve closing the circular process has moved further down. The area representing the work gained increases thereby, and so does the effective result. A drawing to scale would indicate that, with a back pressure of 0.9 atmos., a compression pressure of 3.15 atmos., and an explosion pressure of 19.8 atmos., there is obtained (assuming no other losses) a thermal efficiency, η, of 50 per cent. Even taking into consideration the fact that the waste heat does not provide sufficient power to take care of the gas compression, it would still appear that it is possible to convert into useful work from 40 to 45 per cent of the heat content of the materials of combustion. Such a result is no doubt very promising, as in reciprocating engines the ideal process leads to similar results only under the assumption of compressions in the ration of at least one to ten, and Holzwarth points to such conclusions of theoretical investigation with great gratification in his article of Feb. 28, 1920 in the *Zeitschrift des Vereines deutscher Ingenieure*. In this article he also uses the Schuele diagrams, but in the form employed they hold good only for air and very dilute gases, a defect which has since been corrected and does not appear in the diagrams of Fig. 4.

It is to Schuele that credit should be given for this last step in advance in the theory of gas turbines. His diagram is of such great advantage in considering this new type of prime mover that it deserves a more complete description. Above all, it is remarkable for the great wealth of conclusions that may be drawn from it, notwithstanding its simplicity of appearance.

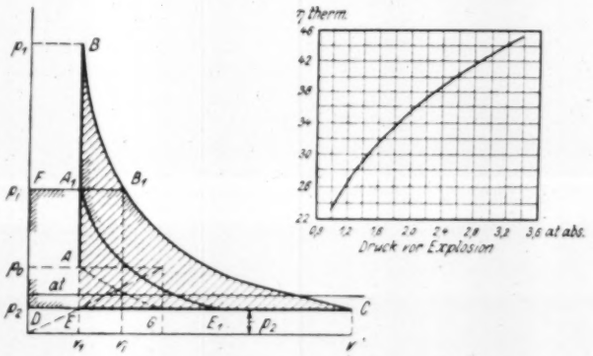


FIG. 2 THE PROCESS OCCURRING IN THE HOLZWARTH TURBINE SHOWN IN THE p-v DIAGRAM

FIG. 3 EFFICIENCY OF THE HOLZWARTH TURBINE EXPRESSED AS A FUNCTION OF PRECOMPRESSION

(*Therm.* = thermal efficiency; *at. abs* = atomospheres absolute; *Druck vor Explosion* = pressure previous to explosion.)

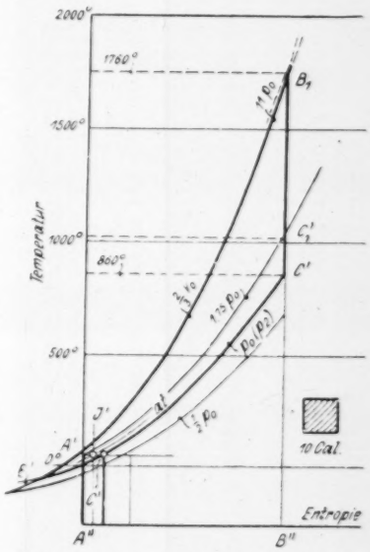


FIG. 4 PROCESS OF HOLZWARTH TURBINE PLOTTED ON A HEAT DIAGRAM

Schuele uses the following reasoning: From the expression already cited above, $dQ = c_v dT + Apdv$, it follows for any process occurring at constant temperature that $dQ = Apdv$, since dT is equal to zero. Furthermore, we have for cases of isothermal expansion and compression the equation

$$dS_T = \frac{dQ}{T} = \frac{Apdv}{T}$$

This, by reason of the equation of state, may be written as

$$dS_T = \frac{ARdv}{v}$$

from which we obtain by integration

$$S_T - S_{0T} = AR \log \frac{v}{v_0}$$

Furthermore, by differentiating the equation of state

$$pdv + vdp = RdT$$

and for constant temperature $pdv = -vdp$, and by introducing this last relation we obtain

$$dS_T = -AR\frac{dp}{p} \text{ or } S_T - S_{0T} = -AR \log \frac{p}{p_0}$$

From this it appears that the entropies at different pressures but the same degree of heat differ from each other by quite an appreciable amount, which moreover is independent of the temperature. At the same time all the curves of pressure are congruous and one may be derived from the other by displacing it by the amount given by the last equation. The consideration of the expression

$$S_T - S_{0T} = AR \log \frac{v}{v_0}$$

leads to the conclusion that all curves of volume are likewise con-

gruous, and each one may be derived from the other by a proper process of displacement. It is therefore sufficient to plot on the heat diagram only one pressure and one volume curve for a given substance, and indicate on the axis of abscissæ a scale from which for a smooth course of p_0/p and v/v_0 one may read the amount to which the given curve should be shifted for the given substance. It is, however, necessary to remember that different scales apply to different gases, but even this difficulty can be taken care of by carrying out calculations for the different gases in terms of mols. Should this be done and the molecular weight of the gas be denoted by m, the following equations hold good for the curves of pressure and volume:

$$m(S_T - S_{0T})_p = -LRm \log \frac{p}{p_0}; \; m(S_T - S_{0T})_v = ARm \log \frac{v}{v_0}$$

However, according to Avogadro the product mAR for all gases is equal to 1.985 kg-cal. From this we find that

$$m(S_T - S_{0T})_p = 1.985 \log \frac{p}{p_0}, \text{ and } m(S_T - S_{0T})_v = 1.985 \log \frac{v}{v_0}$$

and from this it follows directly that if all calculations are made in terms of mols, the same scale applies to all gases. The same situation holds good if we consider the gas in terms of cubic meters at 0 deg. cent. and 760 mm. of mercury pressure. The weight of such a gas is $\frac{m}{22.4}$ kg. and the variation of entropy at the same pressure between the limits T and 273 deg. cent. is

$$\frac{m}{22.4} S_p = \frac{1}{22.4} \int_{273}^{T} \frac{mc_p}{T} dT = \Sigma_p$$

For equal volumes the analogous equation

$$\frac{m}{22.4} S_v = \frac{1}{22.4} \int_{273}^{T} \frac{mc_v}{T} dT = \Sigma_v$$

is found.

The displacements are therefore as follows, as a glance at the equations expressed in terms of mols would indicate:

$$\frac{m(S_T - S_{0T})_p}{22.4} = -\frac{1.985}{22.4} \times 2.306 \log \frac{p}{p_0} = -0.20405 \log \frac{p}{p_0}$$

$$\frac{m(S_T - S_{0T})_v}{22.4} = 0.20405 \log \frac{v}{v_0}$$

From this it would appear that the same scale holds good for all gases dealt with in terms of cubic meters.

For numerical calculations, however, it is necessary to make assumptions as to the specific heat c_p, c_v, the functional relation of which is given in accordance with generally known thermodynamic laws by the equation $mc_p - mc_v = mAR = 1.985$ kg-cal. For air and diatomic gases such as O_2, N_2, H_2, CO, the heat capacity referred to one mol is at constant pressure $mc_p = 6.57 + 0.00106\,T$. For one cubic meter we therefore get

$$\frac{mc_p}{22.4} = \mathfrak{C}_p = 0.2933 + \frac{0.4732}{10000} T$$

and since $\mathfrak{C}_p - \mathfrak{C}_v = \frac{1.985}{22.4} = 0.0886$, it follows that

$$\mathfrak{C}_v = 0.2047 + \frac{0.4732}{10000} T$$

From this it follows that

$$\Sigma_p = \int_{273}^{T} \frac{0.2933}{T} dT + \frac{0.4732}{10000} \int_{273}^{T} dT = 0.6754 \log \frac{T}{273} + \frac{0.4732t}{10000}$$

where $t = T - 273$. In a similar manner it is found that

$$\Sigma_v = 0.4713 \log \frac{T}{273} + \frac{0.4732t}{10000}$$

For all the substances above referred to it is sufficient to plot on the diagram one pressure and volume curve. Likewise, for all the pure gases of combustion generated by combustion with only the theoretically necessary amount of air present, the general equations

$$\Sigma_v = 0.7055 \log \frac{T}{273} + \frac{0.7143t}{10000}, \text{ and } \Sigma_0 = 0.5015 \log \frac{T}{273} + \frac{0.7143t}{10000}$$

hold with sufficient precision. In order, however, to determine the curves which would cover the case of diluted gases of combustion, one has to plot the Σ_p lines for air and the pure gases of combustion. Then the sections of abscissæ located between the two curves are divided in the ratio $\frac{v_e}{v}$, where v_e is the volume of the excess of air and v the total volume of the products of combustion. The points determined in this manner belong to the desired curves. The same process gives the v-curves for the diluted gases of combustion.

Schuele used an interesting graphic process described in the original article for determining the values of Σ_p and Σ_v for carbon dioxide and water vapor. (*Zeitschrift fur Dampfkessel und Maschinenbetrieb*, vol. 44, no. 44, Nov. 4, 1921, pp. 351–354, 4 figs., *t.A*)

Short Abstracts of the Month

AERONAUTICS

Two Hundred and Twelve Miles Per Hour. In tests in December, 1921, at Martlesham, England, J. H. James is said to have established a record of 212 m.p.h., flying over the flying kilometer in a Mars-I machine made by the Gloucestershire Aircraft Co. However, the record has not yet been homologated by the Royal Aero Club. The machine is a biplane driven by a Lion engine. (*Flight*, vol. 13, no. 51, 678, Dec. 22, 1921, p. 838, 1 fig., *g*)

Work at McCook Field in 1921, Maj. T. H. Bane, Mem.Am. Soc.M.E. Brief account of some of the outstanding features of the work of the Engineering Division, Army Air Service.

Among other things is mentioned the 1000-hp. engine now under construction. The engine is said to be of the barrel type and very compact.

Also a duralumin aeroplane has been built and passed its sand test, except for minor defects which it is believed will be corrected. This is the first attempt in this country to build a complete duralumin aeroplane. (*Aviation*, vol. 12, no. 2, Jan. 9, 1922, pp. 41–42, *g*)

Functioning of Supercharger in Altitude Flight, Lt. John A. MacReady. Excerpts from the report of the author on his flight at McCook Field, Sept. 20, 1921, which established a record for altitude. The flight was made on a supercharged LePere P-53 plane.

A peculiar and unusual condition arose during the flight. At the lower altitudes, instead of putting on the supercharger with altitude, it was necessary to gradually take off a little supercharger as altitude was gained. This is explained by the increase of speed of the propeller with altitude, resulting in increased supercharging capacity, which, if not taken off, would cause preignition. There did not appear to be an increase in propeller speed after 35,000 ft. was reached, and from this point on it was necessary to give additional supercharger to keep the supercharger altimeter dial indicating sea-level conditions.

On the ground the speed of the propeller was 1100 r.p.m., but gradually increased to 1680 at 35,000 ft. where it remained until an indicated ceiling of 41,200 ft. was reached. It was expected that the climb would be continued into some region of pressure above the point of 100 per cent supercharger efficiency, but this assumption proved incorrect. Sea-level conditions were reached at 40,400 ft., but from then on only slight altitude was gained, the supercharger dial registering a tremendous falling off. With 100 ft. more altitude, supercharging conditions within the engine went from sea level to approximately 6000 ft. above sea level, and this elevation became the absolute ceiling of the aeroplane. (*Aviation*, vol. 12, no. 2, Jan. 9, 1922, p. 51, *d.A*)

AIR MACHINERY (See also Pumps)

Air Compressors for Marine Diesel Engines

DESIGN OF AIR COMPRESSORS FOR MARINE DIESEL ENGINES, David Bruce. It being impossible to give any definite method of calculating, the first-stage cylinder volume in a marine Diesel engine is made a percentage of the total volume of the working cylinder. The percentage varies from 8 to 10 per cent. Practically all marine-Diesel-engine compressors are of the 3-stage type, though 2-stage machines are also employed as auxiliaries.

The article gives the figures for 2- and 3-stage machines, including the actual terminal figures in each stage, as resolved for final delivery pressures of 1015 and 1215 lb. per sq. in. abs., and also for initial pressures of 12 and 14.7 lb. absolute.

Methods of combining the various stages are described briefly and illustrated with diagrams. The valves used for the suction and discharge are of the automatic type and must be large enough to allow of a maximum air speed of 120 to 130 ft. per sec. through them. To keep within the speed limit in a large cylinder requires such a large valve capacity that in the larger stages two or three similar valves are fitted. In some of the pressure stages in which the diameter of the cylinder is very small, it is sometimes advisable to use small thimble and pocket valves. The article shows the inlet and outlet valves as adopted on small high-pressure stages (Fig. 1), the inlet being a mushroom and the outlet a thimble valve.

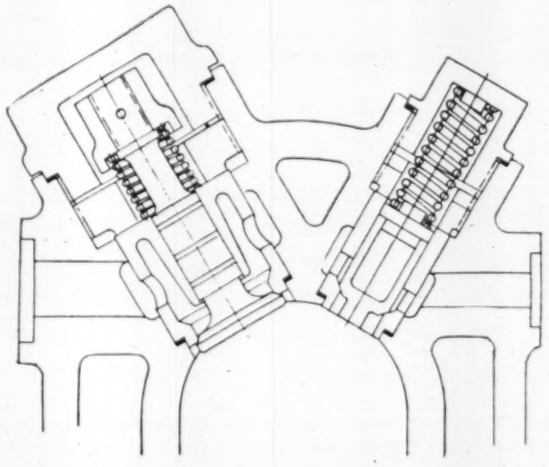


FIG. 1 ARRANGEMENT OF VALVES IN SMALL COMPRESSOR CYLINDERS

The various types of air intercoolers are described briefly and illustrated.

Discussing clearance volumes, the article states that these must be kept as low as can be arranged in accordance with working conditions, although the practice of omitting certain valves, such as the 2-stage delivery valves in small marine compressors, and allowing the next stage suction valves only to provide the separation between the two stages, is undesirable as it leads to a big drop in efficiency of the compressor. (*Motorship*, vol. 7, no. 1, pp. 22–24, 11 figs., *d*)

HANDLING MATERIAL BY COMPRESSED AIR, F. A. McLean. Description of various types of air hoists, of particular interest on account of the inclusion of several tables of figures giving the cost of hauling and lifting with this type of hoist. (*Canadian Machinery and Manufacturing News*, vol. 26, no. 25, Dec. 22, 1921, pp. 19–23, 10 figs., *gp*)

COMBUSTION ENGINEERING (See Aeronautics)

CORROSION

CORROSION OF A PRODUCER-GAS COOLING SYSTEM, Lloyd E. Jackson. Data of an investigation conducted for the Providence Gas Company, Providence, R. I., at the Mellon Institute, Pittsburgh, Pa.

The incentive for this investigation was that at the manufacturing plant of the Providence Gas Company, after six months' operation with coke some producers developed leaks in the producer-gas cooling-water system.

There were good reasons to believe that the corrosion was not due to electrolysis caused by stray electric currents. Acids which might also lead to corrosion were found in numerous samples. The most economical way to treat acid is to neutralize it with lime, but before commencing to give this treatment to water some carefully cleaned test pieces of iron 5 in. by 2 in. by $^1/_8$ in. were suspended in the cooling system at the same points from which water samples were collected. The test pieces were allowed to remain several days and then were removed, dried and weighed. This test was made to obtain data with which to compare future data to be obtained from tests made following successful steps in treating.

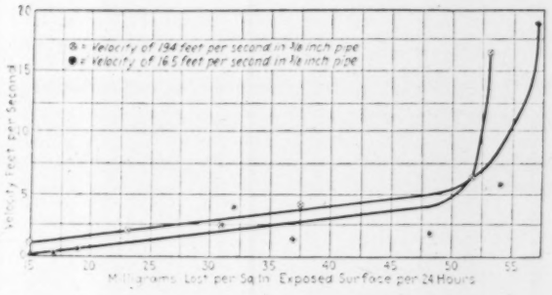

Velocity of 194 feet per second in ¾ inch pipe
Velocity of 165 feet per second in ¾ inch pipe
Velocity, Feet per Second
Milligrams Lost per Sq. In. Exposed Surface per 24 Hours

FIG. 2 EROSIVE ACTION OF COOLING WATER CONTAINING SUSPENDED COKE DUST

Apparatus for treating the water with lime was next installed, the water being at first treated with sufficient lime to make it alkaline to methyl-orange indicator. Tests with suspended iron test pieces showed that the corrosion of iron in water so treated was about half as great as in untreated water. However, methyl orange indicates only free mineral acid, and an attempt was made next to treat the water with sufficient lime to maintain it alkaline to phenolphthalein, which latter shows also acidity caused by dissolved carbon dioxide. This did not prove practical because such amounts of carbon dioxide are present in the producing gas with which the cooling water comes in direct contact, that reasonably large amounts of lime would be required to maintain the water alkaline to phenolphthalein.

Numerous analyses of samples were made also for dissolved oxygen, and they showed that the city water used for making up evaporation losses was highly saturated with dissolved oxygen. Further, as the water gives up its dissolved oxygen in the gas-cooling system, it is continually receiving a fresh charge when sprayed into the cooling pond. Dissolved oxygen, however, is an active corrosion agent, both in neutral and acid solutions and is particularly active in the presence of free mineral acids. To free the cooling water of dissolved oxygen, it was proposed to pass it through filters containing steel turnings instead of coke. Tests with suspended iron pieces showed that such an arrangement cut down corrosion in half. Tests were further made to determine the erosive action of the suspended coke dust in the cooling water. The results are presented in a table in the original article and plotted against water velocity in Fig. 2. From this test it appears that erosion due to suspended coke dust and ashes plays a very important part of the deterioration of the cooling system. In fact, in tests with 6-in. service pipe and a velocity of flow of water of approximately 12 ft. per sec. under average operating conditions, erosion tests showed this pipe to be wearing away at the rate of 55 mg. per sq. in. per 24 hr. The following recommendations were suggested as possible remedies for preventing deterioration of producer-gas cooling system:

(1) Cool and clean the producer gas with fresh water, and permit the water to waste to the bay after going through the cooling system. (2) Treat, cool and recirculate fresh water. The treatment recommended consists of filtration to remove suspended coke dust, neutralization of free mineral acid with lime, and removal of dissolved oxygen with steel turnings. (3) Cool and clean the gas with an excess of bay water and let it waste back to the bay.

In commenting upon these recommendations the author calls attention to the fact that first cold deactivated bay water had no

appreciable corrosive action on iron, but in the presence of hot producer gas, iron in deactivated bay water corrodes about three-fifths as rapidly as in the presence of raw bay water, and that the corrosive action of either kind of water increases rapidly as the temperature rises.

When 60 deg. fahr. or cooler water is available, the producer gas can be cooled sufficiently by pumping the cold water over the condenser and pumping warm water from the decanter over the dust catchers and collecting main. To determine whether warm bay water causes greater corrosion under these conditions, weighed pieces of iron were suspended on the bottom of a dust catcher and permitted to remain there for 14 days; then they were removed and reweighed. Water entered the dust catcher at a temperature of 100 to 110 deg. fahr. and left at a temperature of 110 to 120 deg. fahr. The tests show that practically the same amount of corrosion takes place in the dust catcher as when cold water which has not been deactivated is pumped. This recirculation, whether with bay water or fresh water, should not be practiced, because the water when tested contained excessive amounts of suspended coke dust. Under these conditions it is to be expected that pipes and pumps carrying the water from the decanter to the dust catchers will erode rapidly. Bearing out this contention, several leaks developed while test 6 was in progress.

Tests made to compare bay water with unfiltered recirculated fresh water have shown that the advantage lies with bay water. (*Chemical and Metallurgical Engineering*, vol. 26, no. 2, Jan. 11, 1922, pp. 60–64, 5 figs., *e.A*)

COST ESTIMATING (See Foundry)

ENGINEERING MATERIALS (See also Railroad Engineering

Bentonite, Raymond B. Ladoo. The name "bentonite" has been applied to a series of claylike materials which occur in Wyoming, California and South Dakota in fairly large deposits, as well as in several other states.

It is coming into use for certain purposes in several industries, including its employment as a water softener. No detailed data as to this latter use are given. (*Chemical Age*, vol. 29, no. 12, Dec., 1921, pp. 493–494, *g*)

Metallurgy of Gray Cast Iron

The Problem of Gray-Iron Castings, H. J. Young. The author recommends the necessity of closer control of iron castings, beginning with the ore used for the pig iron. With the aid of tables he shows how such control is possible—in fact, he claims that purchasing an iron today upon its published composition is buying "a pig in a poke." Pig iron of standard ultimate composition would solve nearly all the difficulties of the jobbing foundry and most of those doing more important work.

Regarding the use of an electric or other furnace in conjunction with the cupola (duplexing), he says, first, that what we know about cupola practice is insufficient to enable us to predict that it cannot by itself give what we require. Next comes the question of cost, especially where competition with foreign markets (the abstract is from a British paper) has to be considered. Finally, it should not be assumed without question that the more carbon, phosphorus and sulphur abstracted from the iron, the better will be the metal for the purposes of making castings.

The author considers gray cast iron as a very high-carbon steel, cut up by and surrounding innumerable plates of graphite—in other words, a matrix of steel containing many spaces filled with graphite. This is why cast iron can be machined, the non-homogeneous material collapsing under the stresses produced by the edge of the cutting tool. For the same reason cast iron has little or no elongation.

The truth of these generalizations is well illustrated in the case of a large propeller casting, blades and boss complete, and weighing, say, 11 or more tons. Here the great mass of the boss causes extremely slow cooling of the adjacent parts, the effect getting less and less along the blades away from the boss and also as the cross-section of the blades themselves gets less. In practice, the molten metal flowing to the tips of the blades is almost chilled, and therefore the tips are very hard and brittle and contain but little free carbon. A short distance from the tip this cooling is less severe and more carbon is released, with the consequence that the metal is gray but rather hard. Half way up the blade the section is greater, and the heat given off by the cooling of the boss delays the cooling, hence the metal will be very normal and perfectly gray and machinable. At the root of the blade, where it joins the boss, the cooling will be extremely slow, taking some hours probably, and therefore the iron has time to free itself almost entirely from combined carbon, and when cold is found to be full of large graphite.

Thus does a propeller casting demonstrate the fact that the quantity and size of the graphite is greatly ruled by the rate of cooling of the metal from hot solid to cold solid. It shows how impossible it is to expect a test bar to represent anything but that part of the casting from which it is cut.

The author cites other examples to show that there is a material difference between metal cast in thicknesses of 4.5 in. and of 1 in. This difference would also appear in test bars cut from such castings. (Paper read before the Inst. of Mining Engrs., Dec. 13, 1921, abstracted through *Foundry Trade Journal*, vol. 24, no. 279, Dec. 22, 1921, pp. 497–501, 10 figs., *ep*. To be continued.)

FOUNDRY (See also Engineering Materials)

Foundry Costing

Foundry Costs and Establishment Charges, Daniel Adamson, Mem.Am.Soc.M.E. Discussion of the method of determining costs and establishment charges, with particular reference to British conditions. The indirect charges are divided as between the molten metal and the labor expended on the mold, and are a matter to be estimated for each particular establishment. They should be ascertained at regular intervals, say, every four weeks, and can then be allocated somewhat as follows:

Unallocated labor: 25 per cent of this item to be charged to "metal" and 75 per cent to workmanship account.

Power: 50 per cent to metal and 50 per cent to workmanship.

Light: 20 per cent to metal and 80 per cent to workmanship.

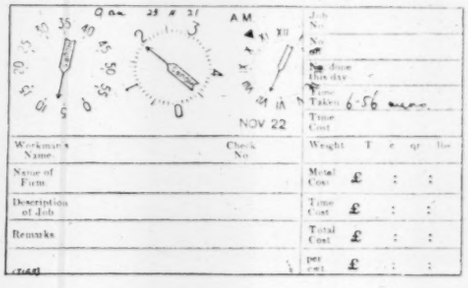


Fig. 3 Job Record For Foundry

Foremen's wages: 20 per cent to metal and 80 per cent to workmanship.

Clerical charges: 25 per cent to metal and 75 per cent to workmanship.

Maintenance of buildings, machinery and plant, mill stores and sundries: 25 per cent to metal and 75 per cent to workmanship.

Depreciation and obsolescence: 25 per cent to metal and 75 per cent to workmanship.

Bank charges: 50 per cent to metal and 50 per cent to workmanship.

Taxes, rates, and insurances: 15 per cent to metal and 85 per cent to workmanship.

Indirect charges can then be converted into percentages of the totals expended during the period for materials and direct labor, respectively. For ascertaining the cost of a particular casting made during that period the percentages would be added to the net cost of material and labor, respectively, and a further sum cover contingencies and profits.

The net cost of materials would include the value of everything charged into the cupola such as pig iron, scrap, coke, limestone. The net cost of workmanship should include as much time as can be booked directly to the job, particularly molders' and coremakers',

also molding-machine time and, in some foundries, dressers' time also. To make the suggestion clearer, an example is worked out, using imaginary figures for purposes of illustration only.

In arriving at the cost of skilled labor booked directly to the job, and upon which the calculations of cost are to be based, attention should be given to the accuracy of the records made, and the most reliable method appears to be that in which job tickets are issued by the foreman to the workman, who in turn stamps these in a time clock at the beginning and end of his time on the order. A typical example of a suitable ticket is given in the article (Fig. 3).

By using the clock in this manner remarkable discrepancies in previous records were discovered, and the conclusion reached that the usual methods of booking time, whether dependent upon the observation of the foreman, or a clerk, or upon the memory or imagination of the workman, are quite illusory and so unreliable as to be almost useless. While the job-ticket system is of great value in other departments of engineering, it is particularly advantageous in a foundry, where it acts also as a check upon the quantity of bad castings made.

The remainder of the article is of interest primarily to British foundrymen. (*Engineering*, vol. 112, no. 2922, Dec. 30, 1921, pp. 894-895, 1 fig., *p*)

GIANT CUPOLA AND MOLDING BIG TURBINE RUNNERS, E. C. Kreutzberg. The I. P. Morris Foundries of the Wm. Cramp & Sons Ship & Engine Building Co., Philadelphia, Pa., have specialized in the production of castings for water turbines. Runners have already been cast weighing 93,000 lb. finished, and still larger castings of the same character to weigh as high as 160,000 lb. are expected shortly. Such huge castings require corresponding foundry equipment, particularly as turbine runners must be very carefully balanced when in use and therefore must be cast with weight uniformly distributed.

Unless the entire casting is made of material at about the same temperature, there is danger of internal stresses being set up. With the ordinary foundry equipment, however, this can hardly be avoided, as hitherto there were no single cupolas capable of giving enough metal for such large castings.

To meet this condition a special cupola was installed capable of delivering 14,000 lb. of molten metal every 15 minutes. The cupola has a shell diameter of 108 in. with a diameter of 84 in. inside for the lining, which is at least 3 ft. greater than the lining diameter of the average cupola. It is claimed that there is only one other cupola of the same size and type in use.

For casting turbine runners an unusual mold is required. Aside from the bottom plate and cover plate, the mold is made up entirely of cores. These are 16 in number and their sides correspond to the 16 veins in the casting. The job of setting up the mold is not an easy one. The cores cannot vary $\frac{1}{16}$ in. from the correct dimensions, and must then be set with absolute precision. Each core is set to overlap the next, and after they have been assembled sheets are placed around the mold and sand rammed between the sheets and the cores. The total weight of the mold with the casting is 135 tons. The construction of the 93,000-lb. turbine runner mold required 28 days. (*Foundry*, vol. 50, no. 1, Jan. 1, 1922, pp. 6-8, 3 figs., *d*)

FUELS AND FIRING (See also Internal-Combustion Engineering)

THE TURBO PULVERIZER. Description of a machine representing the self-contained unit for powdered-fuel firing, used in several important plants in England and on the continent of Europe.

The unit provides a pulverizing mill and fan combined. It comprises a rotor revolving on a horizontal axis in a steel casing. This casing is divided into compartments—the one nearest to the delivery containing a blowing and exhausting fan, while the other contains paddles fitted with loaded blades which, acting by impact, crush and pulverize the coal in stages. The coal is fed into the machine by an adjustable revolving table, the feed regulating the amount of coal burned in the furnace. The air is admitted at two points.

At the works of Edgar Allen & Co., Ltd., of Sheffield, England, the turbo pulverizer operates in connection with a first-heating furnace in the forge, and according to the article reviewed the consumption of fuel was cut nearly in four. No banking through the night is now used, and on restarting in the morning the heat can be brought up in two hours, or from stone cold in three hours.

Advantages of this type of equipment are quoted as low initial price and the fact that fine slack coal can be used with fairly high ash and moisture content too high to be employed for other purposes. (*The Iron and Coal Trades Review*, vol. 103, no. 2807, Dec. 16, 1921, pp. 887, 1 fig., *d*)

HYDRAULICS

THE VARIATION OF ENERGY ABOUT A POINT IN A ROTATING-TYPE HYDRAULIC MACHINE, M. Eydoux. In a previous investigation published in the *Comptes Rendus de l'Acadamie des Sciences*, Oct. 24, 1921, the author has shown that when there occurs a variation of energy along a liquid passage in motion, as happens in turbines and centrifugal pumps, there must of necessity be present a gyratory vector. Working along the same lines, but considering the case of a rotating-type hydraulic machine, the author determines a vector expression for the variation of energy along a line of stream of the liquid.

The author establishes the proper equations for this in terms of the various velocities of flow, and finds from these equations that the components of absolute velocity and the turbulence velocity located in the meridian plane are the only magnitudes determining the variation of energy. As water is a viscous liquid and all turbulent motion which does not turn the machinery is simply a loss of energy, it is obvious that it is desirable to avoid all flow which might give rise to turbulence in an axis normal to the meridian plane.

This treatment of the question makes it possible to express as a function of T (velocity of turbulent flow) the components at one point of the reaction due to the wheel blades expressed in terms of unity of masses, and in this way to find in expressions of usual notation the results previously obtained by Bauersfeld and Lorenz. From these it appears that the reaction of the blades is normal to the relative velocity. If we consider, however, a meridian plane and a section of the blade in this plane, we will find that the work of reaction along that line is zero. Hence the meridianal component of reaction is normal to the section of the blade, which holds good also for the reaction, which being perpendicular to the two curves in the blade is therefore normal to the blade itself. Further discussion of the same subject indicates that the turbulent motion being perpendicular to that of reaction is tangent to the blade.

The article is of a mathematical character not conveniently suitable for abstracting. (*Revue Générale de l'Electricité*, vol. 10, no. 25, Dec. 24, 1921, pp. 907-908, *m*)

INTERNAL-COMBUSTION ENGINEERING (See also Air Machinery, Aeronautics, Railroad Engineering)

Novel Control of Velocity of Combustion in Automobile Engines—Carburetor with Thermal Regulation

A CHEMICALLY CONTROLLED AUTOMOBILE, Geo. Granger Brown. The author discusses briefly the known conditions covering thermal efficiency, and proceeds to the consideration of the reaction velocity, stating that essentially the factors determining the speed of combustion are concentration, temperature and agitation or turbulence. To these he adds catalysis.

For the influence of concentration he derives an equation from which it would appear that so long as the composition of the atmosphere remains constant, its oxygen content has no influence on the gasoline content giving maximum velocity of reaction as far as the law of mass action is concerned.

With the temperature factor the situation is different. The rate of chemical action increases very rapidly with the rise of temperature, and the maximum temperature with such fuels as are used in automobiles is produced by the mixture containing fuel vapor and oxygen in combining proportions. This factor of maximum temperature acts, therefore, in opposition to mass action and tends to decrease the excess of gasoline in the mixture of maximum-reaction velocity demanded by mass action, to an extent depending upon the cooling effect or the specific heat of excess gasoline. But the

mixture of maximum reaction velocity of any combustible gas and air has always an excess of the combustible constituent over the combining proportion due to the influence of mass action (Fig. 4). Fig. 5 shows the more intense and more rapid combustion of a mix-

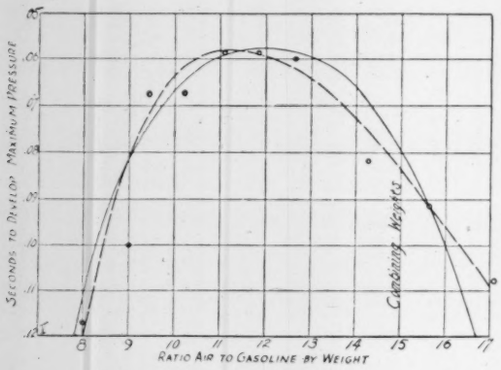


FIG. 4 VELOCITY OF COMBUSTION OF GASOLINE-AIR MIXTURES

ture of 12 parts of air (curve B) over that of a lean mixture of 16 parts of air (curve A) as occurs in an engine cylinder, all other conditions being constant.

Furthermore, increase in the temperature broadens the limits of explosive mixtures and renders explosive mixtures otherwise non-explosive.

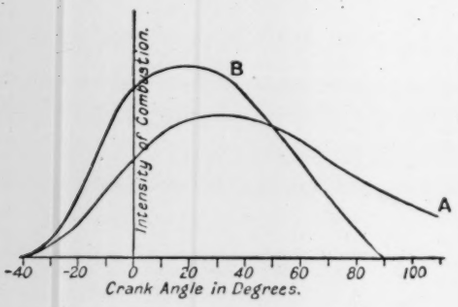


FIG. 5 INTENSITY AND VELOCITY OF COMBUSTION OF 12 : 1 AND 16 : 1 AIR-GASOLINE MIXTURES

Fig. 6 shows the results of presence or lack of agitation obtained on an indicator card after two idle compression strokes in which the turbulence was allowed to die down. The curve AB corresponds to normal firing and the expansion line $A'B'$ corresponds to the second case in which all conditions except decreased turbulence were the same.

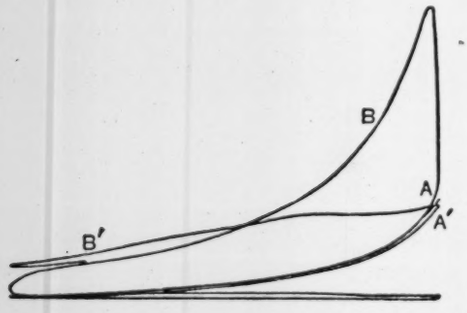


FIG. 6 INDICATOR DIAGRAM OF TURBULENT AND QUIET MIXTURES

Pressure has been found to have practically no influence upon speed of reaction, so long as temperature remains constant. However, increased compression in an engine means increased temperature, since the absolute temperature varies as the absolute pressure in adiabatic processes.

In addition to the complete combustion of gasoline, partial combustion to aldehyde, carbon monoxide, and possibly hydrogen, also takes place, along with some decomposition of the hydrocarbon fuel.

The stability of the hydrocarbons is greatest with the lowest paraffin—methane. Ethane is less stable and can be very rapidly decomposed at 1100 deg. cent. It has been estimated that at 1500 deg. cent., 0.036 sec. is the time required for complete decomposition of the hydrocarbons. At this temperature, which is attained in the gasoline engine, the time of decomposition is of the same order as that of the ignition period.

These two reactions are taking place simultaneously in the cylinder as the mixture is exploded, combustion producing heat and work, and decomposition of the gasoline generally absorbing heat and depositing carbon residue. As decomposition of the fuel takes place much more rapidly at higher temperatures, the lower temperature developed by the combustion of lean mixtures is of advantage in decreasing and eliminating fuel knock and also deposition of carbon in the cylinders. Sir Dugald Clerk has accomplished the same result by introducing cold exhaust gas into the cylinder charge. This method is more effective in reducing the temperature, but

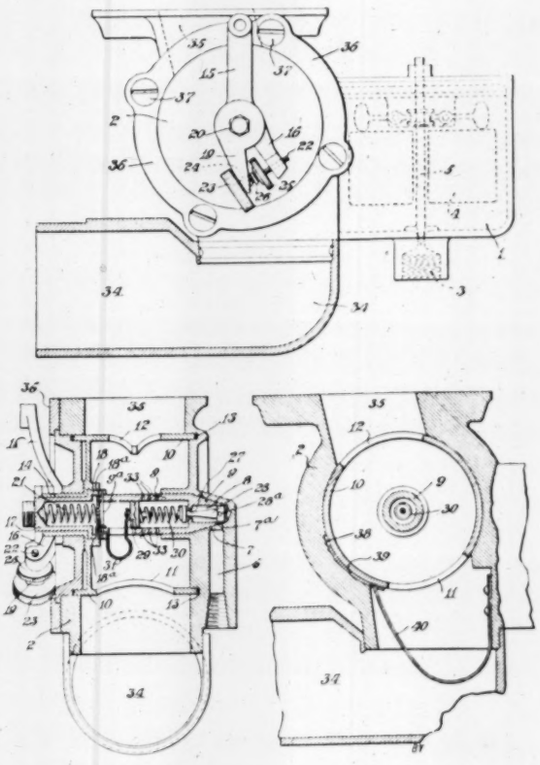


FIG. 7 CONSTRUCTION OF CARBURETOR GIVING AUTOMATIC CONTROL

probably not so efficient, owing to the higher specific heat and radiation loss of carbon dioxide over air. Also, it introduces complications in the design and operation of the engine.

The author carried out a series of tests to determine the action of a gasoline engine subjected to various conditions of temperature and concentration of mixture.

The most interesting parts of these tests are those made with the carburetor shown in Fig. 7. The gasoline enters the float chamber 1 at 3 and passes through duct 6 up to the gasoline valve made by part 7 in the casing and part 7a in the stem valve 9, which is in the axis of the drum throttle 10 containing the air inlet 11 and the mixture outlet 12. The gasoline valve can be adjusted in relation to the throttle by the thumb screw 23 and locked in place by the nut 20, so that when the throttle lever 15 is moved the gasoline valve moves in unison with the throttle. The mixture outlet and air inlet are so calibrated that the suction in the mixing chamber is constant so long as the engine is running under "normal load." If the engine is running under any load greater than "normal" for that particular throttle position, the suction in the manifold and the mixing chamber will be less.

This variation in the manifold suction is utilized to vary the

mixture proportions in the following manner: Within the valve stem 9 is an opening, 27, in which the governor 28 is free to reciprocate endwise of the valve stem 9. This governor 28 has a taper shank which restricts the effective area of the opening 27 by an amount corresponding to the section of the taper shank of the governor which happens to be within the opening.

The stronger the suction in the mixing chamber, the stronger will be the flow of fuel and the greater will be the restriction of the opening 27, as the pressure of fuel flow upon the head of the governor compresses the spring 30, making the larger part of the taper effective and to that extent closing the fuel opening 27.

The position of the governor is also controlled by the position of the sliding block 29. The position of this block 29 is determined by the bimetal thermal regulator 31, which is fastened to the valve stem at one end and at its other end rests in a socket in block 29. Upon an increase in temperature the thermal regulator 31 curls up in a direction to move block 29 to the left and permit the governor 28 to move a like distance toward the left, thereby restricting the opening 27 an amount proportional to the movement of the thermal regulator. Upon a decrease in temperature the thermal regulator uncurls, causing the governor 28 to move a like distance toward the right, and exposing a greater effective area of the opening 27.

It has been found possible to calibrate this governor and thermal regulator to obtain automatically any desired change in mixture proportion upon change in engine load or change in temperature. It is possible to compensate simply for the decreased density of air and decreased viscosity of fuel with increasing temperature, or further to restrict the flow of gasoline so as to obtain always the leanest possible or most efficient mixture. Likewise the change in mixture proportion with changing engine load may be simply sufficient to compensate for decreased turbulence to prevent missing and backfiring; or may be sufficient to change from the most economical or efficient mixture under normal conditions to the most powerful mixture when the engine is heavily loaded.

This carburetor is supposed to deliver a definite mixture of gasoline and air for each condition of temperature and load. (Paper before the Division of Industrial and Engineering Chemistry, American Chemical Society, September, 1921, abstracted through *The Journal of Industrial and Engineering Chemistry*, vol. 14, no. 1, Jan., 1922, pp. 6–12, 20 figs., *ted*)

MACHINE PARTS

BELTING ARGUMENT DECIDED BY CORNELL TESTS. Late in the summer of 1921 tests of the capacity of the grain and flesh sides of leather were begun by the Leather Belting Exchange in its research laboratory at Cornell University. These tests were carried on under the direction of R. F. Jones, director of the laboratory, and covered a period of two months of continuous work.

For the experiments five 4-in. single belts 30 ft. long were used. They came from various manufacturers and weighed from 16 to 18 oz. per sq. ft. Every effort was made throughout the tests to standardize conditions and reduce the probable errors to a minimum. All five belts were run long enough before the experiment to be thoroughly "run in," and when the records were taken had reached a condition of constant capacity.

The method of procedure was to take horsepower readings from the belts, first when running on the grain side and then when running on the flesh side, the power being gradually increased until about 4 per cent slip was reached.

In considering the results it must be remembered that a leather belt is at its lowest point of capacity when new, due partly to the elasticity of the leather and partly to the character of its surface. The newness of the surface makes it necessary to "run in" the belt when testing it; that is to say, the belt must be run for a sufficient time to permit it to reach its maximum capacity for power transmission. As an example, one belt under test at the Cornell Laboratory transmitted 12 hp. at a slip of 1.2 per cent when first put on the pulley. After five hours' running it reached 19 hp. with the same percentage of slip and the same tension. At the end of 13 hours it transmitted 24 hp., and 31 hp. after 20 hours, with a slip of 1.6 per cent. According to horsepower tables the scheduled transmission should have been 26 horsepower.

Space prevents a review of the results of the individual tests, but they indicate clearly the superiority of the grain side. Under reasonable shop tension the flesh side will average only 50 to 60 per cent as much horsepower as the grain side. At higher tensions, however, the flesh side will average from 50 to 100 per cent as much power as the grain side, depending on the belt, the tension and the conditions of service. (*Power*, vol. 55, no. 2, Jan. 10, 1922, p. 66, *d*)

MACHINE SHOP (See Management)

MACHINE TOOLS

ATTACHMENT FOR CUTTING SPUR GEARS ON THE SHAPER. Description of a device placed on the market by a British firm (the illustration in the original article is not suitable for reproduction). The attachment operates on the generating principle, so that single-point tools cut from the bar and ground to a straight-sided rack form are employed. Gears of module, circular or diametral pitch, can be readily cut, the tools being ground to graduated gages. The attachment is intended primarily for use with single-point tools, but rack-form cutters with multiple teeth can be used also. Stepped cluster gears, such as are commonly used in motor-car gear boxes, can be readily handled on this attachment, though frequently impossible of access with milling cutters.

The attachment is said to be readily applicable to standard-type shapers. The only permanent alteration to the shaping machine is the cutting of a spline in the cross-feed screw to receive a pinion $2^1/_4$ in. in diameter. The existing feed motion is utilized, the cross-feed screw being geared up through change wheels and a chain and sprocket transmission to a 60-tooth $^3/_8$-in. pitch steel-worm dividing gear. The combined sliding on the cross-slide and turning on the worm wheel produces a rolling motion. The dividing is effected by hand, through a dividing plate and plunger mechanism. (*Engineering Production*, vol. 3, no. 64, Dec. 22, 1921, pp. 587, 1 fig., *d*)

MANAGEMENT

Conditions Governing Fatigue of Workers—Wattmeter Method of Measuring Human Effort in Polishing Work

MOTION STUDY IN METAL POLISHING. Data of an investigation, by means of a wattmeter, of the process of roughing, carried out under the auspices of the Industrial Fatigue Research Board in England. The instrument used is a recording wattmeter giving a continuous graphical record of the amount of electrical energy expended by the motor in use.

In the roughing process (removing imperfections and scratches from the surface and edges of the metal by means of a wooden wheel covered with a leather tire and rotating at a high speed), the thrusting of the article against the buffing wheel results in a frictional retardation of the wheel, and the amount of energy expended by the motor to overcome this friction is accurately marked upon the chart.

From the nature of the process this friction cannot be caused passively. The operator cannot just lean the article being roughed, a table spoon in this case, against the wheel, and therefore must exert effort, and the amount of friction produced is directly dependent upon the effort. Hence the height of the individual strokes above the zero line (energy expended by the motor in revolving the buffing wheel idle) made by the pen of the wattmeter on the chart can be assumed to correspond to the amount of effort put forth by the operator (rougher).

Since the wattmeter records every stroke of the rougher against the wheel and also every pause between the strokes, a graph such as Fig. 8 is automatically obtained, giving the complete time study of the operation under investigation.

Each operator in turn was set to work at the spindle driven by the motor to which the wattmeter had been attached and was observed at her work for two days, during which time she was kept supplied with spoons. In analyzing the records, detailed examination was confined to the roughing of the backs of the bowls. This particular portion of the spoon was selected, first because the surface is large and therefore likely to give evidence of any fatigue that may exist; second, because long heavy strokes are generally applied, and third,

because the work is not complicated by any difficult corners or pattern.

The following method was adopted in examining these charts. The total time taken to rough four bowls, and the average time per bowl was ascertained from the wattmeter records. The number of strokes per spoon was counted and each stroke measured, and in this way the average length of each stroke in centimeters on each record was obtained. Finally, the time taken on each four bowls was divided by the total number of strokes, thus giving the average duration of each stroke.

The results obtained from two of the operators are given in a table in the original article. From this it would appear that one of the operators exerted a far greater pressure than any of the others. As the work of a second operator was, however, of excellent quantity, it would appear that the additional pressure exerted by the first was simply unnecessarily fatiguing her, and at the same time wearing out the roughing wheel.

The examination of these tables shows further that in all instances the time taken to perform a unit of work increased toward the end of the day. The number of strokes made by each worker was

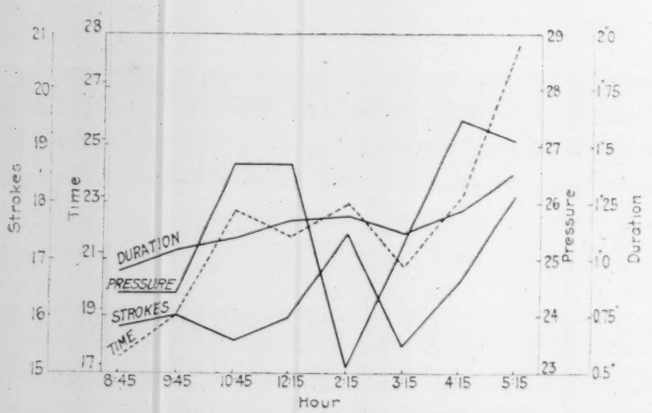


FIG. 8 DURATION, PRESSURE AND STROKES IN ROUGHING FOUR TABLE SPOONS COMPARED WITH TIME REQUIRED

about the same, but the height of each stroke, which is a comparative measure of the pressure exerted, showed a marked tendency to increase during the afternoon. The duration of the stroke also increases during the day, especially in the late afternoon; this would indicate that the operators growing tired were inclined to give more vigorous strokes and take longer over each individual stroke.

Two factors are present which together determine the duration of the stroke, namely, the length of time that the pressure of the spoon against the wheel is sustained, and the length of the pause between successive applications of this pressure. An examination of the charts shows quite clearly that both these factors were in operation, and that toward the end of the day's work both operators made more sustained strokes, and also paused for a longer time between each stroke.

Another method of measuring the wattmeter records was used, in which the areas enclosed by the recording pen of the meter were measured by a planimeter. These measurements give the energy expended by the motor in order to overcome the frictional retardation caused by the worker pressing the spoon against the revolving wheel, and so give an approximate measure of the human effort exerted.

The records obtained by the first method lead to some interesting conclusions. Fewness of strokes corresponds very closely with high output, or, in other words, implies increased duration and good pressure if good output is to be maintained.

The accounts of earlier experiments carried out in time and motion study have described the large part played by rhythm in the easy performance of most industrial operations, and probably rhythm is the determining factor in this case too. In the earlier part of the day, when the worker is fresh, the work is done rhythmically and the results are satisfactory. The nearest approach that can be made to instill rhythm is by modifying the number of strokes. It will be seen that the number of strokes per spoon varies little in the morning, and that greater variations are introduced in the afternoon. When fatigue increases, the natural rhythm of the body seems to break down and conscious effort is invoked in order to do this work.

The records of the present tests would indicate, however, that as the worker becomes fatigued, the coördination between the factors represented by the curve of rhythm becomes more and more disturbed. Fatigue has the effect not only of slowing the reaction times, but also of causing a certain lack of motor control, resulting in increased pressure and increased number of strokes. The tired worker is not only working slower than when she is fresh, but is also expending her energy extravagantly. From this it would seem that in order to increase the efficiency of certain industrial operations, attention must be paid not to speed nor even to the elimination of unnecessary movements as an end in itself. The first thing to do is to devise a rhythmic method of doing the work, which may be done by means of limiting the number of strokes. Then proper instructions must be given to the method.

The present experiments have shown that other factors besides the lack of rhythm make for fatigue, such as putting too much effort into the work. (*Engineering and Industrial Management*, vol. 6, (New Series), no. 26, Dec. 29, 1921, pp. 738–742, 3 figs., *ep*)

MEASURING APPARATUS

Pressure-Corrected Recording Steam Meter

THE KENT-HODGSON STEAM METERS, J. L. Hodgson. Description of steam meters developed by the writer together with a British concern.

Fig. 9 shows in a diagrammatic form the essential parts of the pressure-corrected steam meter. An orifice, *O*, is placed in the steam main and creates a difference of pressure $(p_1 - p_2)$ which is trans-

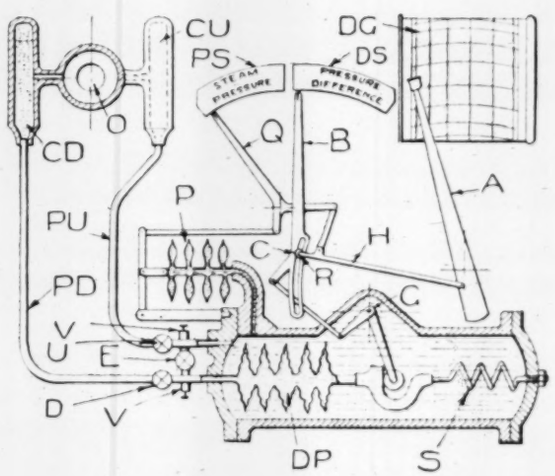


FIG. 9 DIAGRAM OF ESSENTIAL PARTS OF KENT-HODGSON STEAM METER

mitted through the pressure pipes, *PU* and *PD*, to the two sides of the battery of diaphragms, *DP*, in the recorder. These diaphragms are held apart by a spring, *S*, so that any increase in the difference of pressure causes them to come together. Their motion is transmitted through the gland *G* to the slotted arm *B*, which is pivoted at *C*. In this way *B* is given an angular motion, which is proportional to the difference of pressure existing across the orifice. The pressure of the steam is transmitted through the pipe *PU* to the tempered steel diaphragms *P*, which expand with increase of pressure and give the pointer *Q* a motion proportional to the pressure. This motion causes the connecting rod *H*, which carries the roller *R*, to descend an equivalent amount. The motion transmitted through the connecting rod *H* to the pen arm *A* is thus proportional to the product of the angular motion of the arm *B* [which depends upon $(p_1 - p_2)$] and of the linear movement downward of the roller *R* [which depends upon the absolute pressure of the steam p_1].

If the superheat of the steam be assumed constant, the formula

$$Q = K\sqrt{(p_1 - p_2)\ p_1} \text{ pounds per hour}$$

(where K is the constant depending upon the size of the orifice and the size of the main, and upon the superheat or wetness of the steam) represents approximately the steam flow through an orifice, so that if the diagram DG is divided on a square-root basis it will show

$$\sqrt{(p_1 - p_2)\ p_1}$$

or by suitably numbering the lines on the diagram it will show

$$K\sqrt{(p_1 - p_2)\ p_1}$$

i.e., Q.

Actually, the law of steam flow through an orifice is slightly more complicated than that represented by the above formula. The meter is made to operate according to the true and more complex formula by correctly adjusting the initial angles of the various cranks.

Scales PS and DS, showing the steam pressure and the pressure difference across the orifice, are provided, which enable the adjustments of the meter to be checked at any time.

The error introduced by not correcting automatically for the superheat or wetness of the steam is small. A variation of 20 deg. fahr. in the superheat or 2 per cent in the wetness, corresponds to an error of about 1 per cent. Usually the superheat and the wetness are fairly constant, so that their variations can be allowed for by means of a table of corrective factors without introducing any material error.

It will be noticed, on reference to Fig. 9, that the meter body is full of water, and that two cooling chambers, CU and CD are provided. The function of these cooling chambers is to condense the steam which passes through the pressure holes on the upstream and downstream sides of the orifice. So long as the water level in these cooling chambers is *above* the horizontal center line on which the pressure holes are drilled, the true difference of pressure will be transmitted to the recorder. The portions of the cooling chambers below the level of the pressure holes provide reservoirs of water which prevent steam reaching the recorder when any air that may have separated in the pressure pipes is being blown away through the air vents V.

Valves U and D enable the meter to be shut off from the main, and the valve E enables the meter to be "equalized" (and the zero of the differential pressure pointer checked).

If the meters are overloaded, the corrugations of each pair of the diaphragms DP fit into one another, so that no damage is done. The meters are fitted with other protective devices (not shown in the diagram) which prevent them from being damaged if wrongly connected up, or if one pressure is turned on before the other. These protective devices have proved to be a most important feature of the meters.

The recorder referred to above and the orifice tipping are shown in considerable detail. This latter consists of an orifice plate fastened into a steel ring provided with a head through which the pressure holes are drilled, but no pressure holes have to be drilled in the pipe line. The coefficient of discharge of every orifice is determined by calibration with water. This has been found to be fully sufficient for most practical purposes, although where high precision is necessary, means illustrated and described in the original article must be used. The meter is not suitable for measuring pulsating flow unless the pulsations are reduced to a negligible amount at the point where the orifices are inserted.

The original article describes also a counter attachment which may be fitted to these meters. It is not described here as it does not differ materially from the fairly well-known integrating mechanism used in Kent water meters. (*South African Engineering*, vol. 32, no. 12, Dec. 31, 1921, pp. 243–245, 5 figs., *d*)

MOTOR-CAR ENGINEERING

RICKENBACKER-SIX AUTOMOBILE, J. Edward Schipper. The new car incorporates some departures from usual engineering practice. For example, it has flywheels at the front and rear of the engine, which is claimed to minimize vibration. The cylinder block and the upper part of the crankcase are cast together, and the block casting is so designed that the chain case and the flywheel housing are bolted on, thus simplifying casting and machining processes.

The usual practice in finishing the connecting rods is to check the alignment of the rod on a gage, and if it is not true to bend the rod so that it will check properly on the gage. On the new car a small end of the connecting rod is ground to assure alignment, as was done by some of the manufacturers of aeroplane engines during the war. This alignment is important in eliminating side friction of the piston, insuring an easier- and smoother-running engine.

The clutch has a Raybestos facing, running in a bath of oil. It is claimed that the combination of this facing and the oil bath eliminates any possibility of burning and at the same time insures a smooth action. (*Automotive Industries*, vol. 45, no. 26, Dec. 29, 1921, pp. 1258–1261, 7 figs., *d*)

POWER GENERATION

INTERNAL-TERRESTRIAL HEAT AS AN IMPORTANT SOURCE OF ENERGY. Whether the theory of a molten central portion of the terrestrial globe is correct or not, there is no doubt that the temperature of the interior increases with the distance from the surface of the earth.

The observed increase amounts to about 3 deg. cent. for every 100 m. of depth, but there are reasons to believe that as the depth increases beyond a certain point the rate of increase in temperature becomes even greater than that. In any event, there is no question but what the temperature at some attainable distance from the surface is quite considerable, and the question is whether it might not be possible to utilize this heat commercially. The well-known scientist, de Moupertius, was the first who called attention to this possibility. In fact, partly on account of this and partly for solving many geological problems, he suggested to the Prussian Academy of Sciences in the middle of the 18th century that a shaft be dug to the center of the earth, a proposition which was vigorously ridiculed by his colleague in the membership of the Academy, the famous Voltaire.

The main obstacle in the way of commercial utilization of the internal heat of the earth is the thickness of the superficial layer over and above the sixth strata where sufficiently high temperatures obtain under the influence of the magma.

As a rule the surface layer is supposed to extend from 15 to 25 km. (10 to 16 miles). However, it is of uneven thickness and in some places, as, for example, near the hot springs in the Yellowstone Park and New Zealand, must be quite thin, possibly only a few hundred feet thick. In fact, in such places saturated steam comes naturally from the ground with temperatures of the range of 300 deg. cent. (572 deg. fahr.).

Of late Sir Charles Parsons has shown an interest in this problem. The question appears to be within technical possibility, but of quite uncertain economic practicability, at least under the conditions of today. (*Rauch und Staub*, vol. 12, no. 3, Dec., 1921, pp. 16–18, *g*)

POWER PLANTS (See Measuring Apparatus)

POWER-PLANT ENGINEERING (See Corrosion)

PRODUCER GAS AND GAS PRODUCERS (See Corrosion)

PUMPS

Operation in Parallel of Cen rifugal Pumps and Fans

OPERATING PUMPS OR FANS IN PARALLEL, J. C. Hobbs. Discussion of problems encountered in parallel operation of centrifugal pumps. Almost any properly designed fan or pump will perform satisfactorily if operated alone, but when two pumps discharge into the same distribution system operating in parallel certain requirements must be satisfied or trouble will occur. The situation is somewhat similar to the operation of electrical generators in parallel, and in order that fans or pumps operate properly they must have proper operating characteristics and the method of regulation must be correct. By characteristics is here meant the interrelations

between pressure produced, output, horsepower and speed, which may be expressed in the form of curves.

Figs. 10 and 11 show respectively the pressure characteristics that

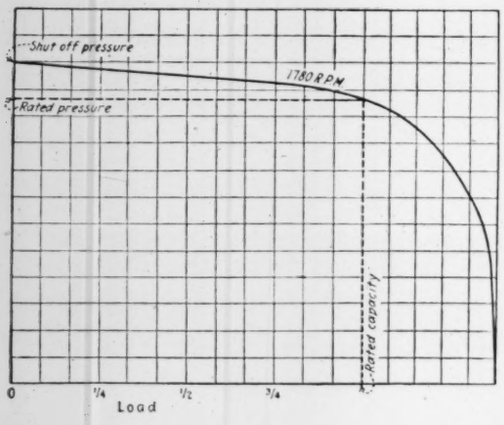


Fig. 10 Typical Pressure Characteristic of Fan or Pump Giving Satisfactory Operation in Parallel

are favorable and unfavorable to operation in parallel. In Fig. 11 the characteristic curve, instead of being flat, has a hump, showing that there are two outputs having exactly the same pressure and

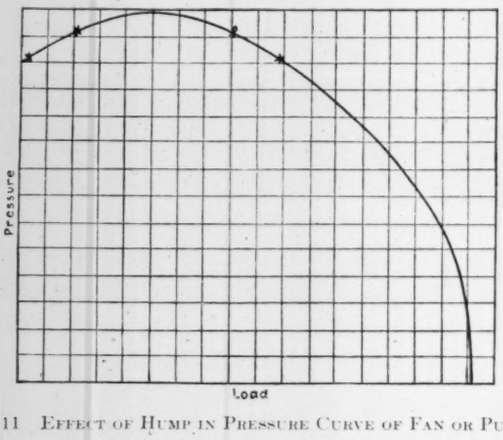


Fig. 11 Effect of Hump in Pressure Curve of Fan or Pump

speed. If two pumps with such characteristics are operated in parallel and discharge against the same pressure, one of them might be on the upward part of the curve and the other on the

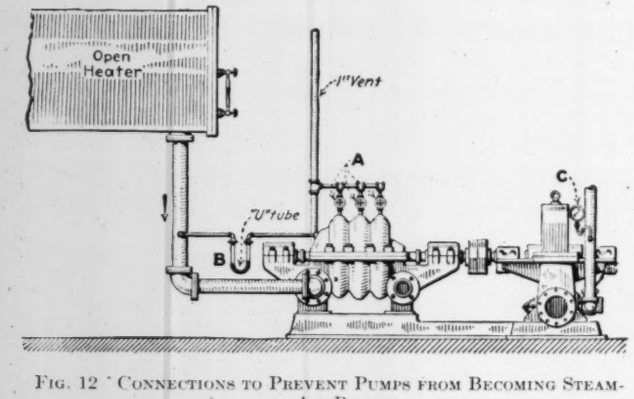


Fig. 12 Connections to Prevent Pumps from Becoming Steam- or Air-Bound

downward part, thus causing an unequal distribution of the load.

This condition is not so serious in cases in which steam-turbine drives are used, but with motor drives in which the speed is practically constant unsatisfactory performances will occur.

With a steam-turbine drive there is the possibility of one of the pumps being "backed off the line." When this occurs, there is danger of the pump becoming air-bound, and the rotor, in rubbing against the dry seal rings, will likely cause damage. Instances have occurred in which parts of the bronze impellers and seal rings have melted, owing to the large input of power from the turbine shaft being converted into heat through friction.

It is not desirable to try to regulate the pressure between excessively narrow limits, because hunting action of the governor and pressure-control valve may occur. The desirable form of characteristic is one in which the discharge pressure drops slowly from zero load up to a point beyond the full capacity rating, and then drops off suddenly.

The possibility of damage to a pump on account of becoming steam- or air-bound has been reduced, if not eliminated, by provisions indicated in Fig. 12. This shows a scheme of piping which can be used in connection with open heaters to prevent the first stage from becoming steambound. The arrangement should be installed on each pump operated in parallel, whether it has the proper characteristics or not, because a small amount of trouble with the pressure governor is liable to divide the load unequally at any time, and one of the pumps may cease to discharge water when the total load becomes light.

A metering arrangement on the discharge of the pump is desirable, such, for example, as the U-tube in Fig. 12, which is installed in such a way to use the friction head through the suction piping for approximately indicating the flow. Such a meter does not measure the exact quantities flowing, but shows relatively the load on the different pumps.

The original article discusses in some detail the effect of using different shapes of impeller blades. (*Power*, vol. 55, no. 2, Jan. 10, 1922, pp. 58–60, 6 figs., *p*)

The "Hydrohoist" Endless-Rope Pump. Description of a novel variation of the endless-rope pump made by a British concern. In this pump an endless flexible wire rope is used having threaded on it a series of small pressed-steel cups, both the rope and the cups being galvanized. Each bucket or cup is made in the press and is fitted in the center with a pressed thimble which acts as a spacing piece and through which the flexible rope is threaded. The standard size of the cups is $1^1/_2$ in. in diameter and the rope works over pulleys 14 in. in diameter.

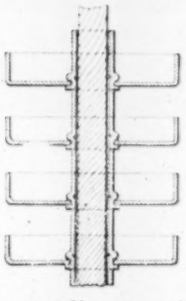


Fig. 13 "Hydrohoist" Endless-Rope Pump

The manufacturers state that with an immersion of 3 ft. and rope speed of 600 ft. per min. the delivery is 3500 gal. per hr. This is due to the fact that not only are the buckets completely filled with water, but in addition a large quantity of it is carried upon the outside. The pump can be worked by hand on lifts as high as 150 ft. (*Engineering*, vol. 112, no. 2918, Dec. 2, 1921, p. 759, 1 fig., *d*)

RAILROAD ENGINEERING

Wheels for Railway Rolling Stock. Description of a new process for producing disk-center wheels developed in England in 1921 and carried on at Coventry by Powell, Brett, Ltd. The process consists in turning out wheel centers in the shape of drop forgings by means of special hammers.

The wheel centers are produced direct from an ingot by a special process, and the cast condition of the steel under powerful drop hammers is broken down into a proper forged state. The final operation of stamping ceases practically at the critical period of temperature of the steel, and the center leaves the dies with the material in what is said to be an ideal state, uniform in shape, perfectly balanced, and possessing a ductility and tensile strength leaving nothing to be desired for this class of steel.

No more information is given as to the process of manufacture, but some data of tests are published. It is said, however, that the production of wheel centers by this method involves the employment of a very powerful drop hammer of special design. The tup

and dies used in the final operation are shown in one of the illustrations. (*The Railway Gazette*, vol. 35, no. 27, Dec. 30, 1921, pp. 1000–1002, 6 figs., *d*)

GASOLINE-DRIVEN RAIL CAR. Description of a car manufactured by the J. G. Brill Co., on a chassis made by the International Motor Co., and in design following essentially the Mack automobile truck. The car has seating capacity for 31 passengers, operating speeds up to 30 m.p.h., and weighs about 11,000 lb.

The Gilmore & Pittsburgh R. R. has recently placed one of these cars in service, but having space for the accommodation of baggage and seating 17 passengers. The railroad runs from Armstead, Mont., to places in Idaho through a mining country with severe grades as high as 6 per cent. The snows in that section of the country are so severe that at times it is impossible to operate steam trains for a week or ten days at a time, but except in the worst snow the car has been able to operate successfully.

Another instance of the operation of a gasoline rail car having proved an effective means of stimulating passenger traffic and curtailing operating costs, is provided in the case of the Narragansett Pier Railroad Co., in Rhode Island. This railroad is eight miles long and had the competition not only of automobiles but until recently of an electric line (abandoned in Nov., 1920).

The comparison of operating costs of light steam trains and gasoline rail cars in local passenger service shows that the cost per mile on a steam train is $0.95, as compared with $0.14 to $1.21 for the gasoline car. In one instance the cost was $1.56 for the steam train and $0.25 to $0.38 for the gasoline car.

The company has also designed a larger car, to seat 35 passengers in addition to the baggage space.

Comparisons of cost per seat per mile between the steam train and gasoline car show a striking difference in favor of the latter, often exceeding 50 per cent. (*Railway Review*, vol. 69, no. 26, Dec. 24, 1921, pp. 860–863, 4 figs., *dep*)

Sandberg Sorbitic Steel

SANDBERG SORBITIC STEEL FOR TIRES. References have occurred in the engineering press to Sandberg sorbitic steel, and tests are being carried on in this country on rails made of this material. On account of this, the information contained in the present abstract may be of interest. As known from the general metallurgy of steel, the microstructure and physical properties of steel depend on its rate of cooling. Slow cooling produces pearlitic condition, with softness and ductility. Sudden cooling from a temperature above the upper critical point produces martensitic conditions, and makes the steel intensely hard and correspondingly brittle. Sorbite is softer and tougher than martensite and harder than pearlite, and is obtained by a slower rate of cooling than that used to produce martensite but not slow enough to create the pearlitic condition.

The method used in the Sandberg process consists of heating the steel to a temperature above the critical point, and then cooling it so slowly that the martensitic condition is not retained and yet the cooling is sufficiently rapid to offset the pearlitic stage being reached. The cooling is done by blowing air or steam on the heated steel. In making tires for railroad wheels they are cooled by being placed one at a time on a revolving table. Moist air is then drawn through branch pipes and nozzles on to the tread of the tire.

The results given in Fig. 14 refer to a test of railroad-wheel tires, all from the same cast of steel. The third line refers to tires cooled in the atmosphere but not reheated. The railroad tires were 2 ft. 9½ in. internal diameter and of a section 5⅝ in. wide and 3⅜ in. deep in the middle of the tread.

The original article contains microphotographs showing very clearly the difference in structure between the treated and untreated steel. The steel in these tires contained 0.73 carbon, 0.313 silicon and 0.74 manganese. The process is said to have been successfully applied also to steels of lower carbon content. (*The Railway Gazette*, vol. 35, no. 27, Dec. 30, 1921, pp. 991–993, and 999, 6 figs., *ed*)

SPECIAL MACHINERY (See Fuels and Firing)

SPECIAL PROCESSES (See also Railroad Engineering)

GEAR MANUFACTURE BY UPSETTING. At the new shop of the Amforge Company recently completed at Chicago a method was developed for the production of gear parts which it is claimed gives a stronger product than hammer forging.

In making these gears round bar steel of forging quality is used after close inspection for seamy stock. The bar is always forged horizontally and forced into the dies by the headers in two or three operations. In the finished pinion the grain of the steel is such that teeth will be cut against it. As a further advantage for the upsetting method of gear manufacture, it is claimed that it does not tend to crystallize the steel as drop forging is apt to do at times.

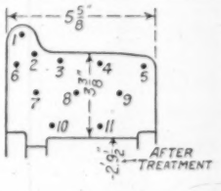
It may be mentioned in this connection that the process of upset forging is practically in its infancy, the plant of the Amforge Company being the only one in the world devoted exclusively to the manufacture of upset forgings. This new method has been developed only within the last few years, but this development has been so rapid that it is estimated that 250 upset-forging machines are now operating on commercial forgings. (*The Iron Age*, vol. 109, no. 6, Feb. 9, 1922, pp. 401–404, 5 figs., *d*)

STEAM ENGINEERING (See Measuring Apparatus)

SANDBERG SORBITIC STEEL. RAILWAY TYRES 2' 9½ INTERNAL DIAMETER. 5⅝"×3⅜" SECTION.

ANALYSIS { CARBON .73 SILICON .313 MANGANESE .74 SULPHUR .033 PHOSPHORUS .038 } ALL TYRES MADE BY THE UNITED STEEL COMPANY.

TYRE Nº	CAST Nº	TREATMENT	DROP TESTS									TENSILE TEST			
			10′	15′	20′	25′	30′	30′	30′	30′		BREAKING STRESS TONS □″	YIELD POINT TONS □″	ELONGATION %	REDUCTION %
1	6861	FULL SANDBERG	5/8	1″	1 7/16″	1 13/16″	2 1/4″	2 5/8″	3 1/16″	3 3/8″	NOT BROKEN	76·4	58·0	14·0	15·8
2	6861	COOLED IN ATMOSPHERE REHEATED TO 850°	3/8	1″	1 1/16″	2 5/8″	3 9/16″	4 15/16″	5 1/16″	BROKE AT BOTTOM.		58·21	—	13·0	18·3
3	6861	COOLED IN ATMOSPHERE	3/8	15/16″	1 5/8	2 5/16″	BROKE AT BOTTOM.					57·32	—	10·8	10·08



BRINELL NUMBERS. 3,000 KGS. ON 10 M/M BALL FOR 15 SECS.

Nº	1	2	3	4	5	6	7	8	9	10	11
1.	331	311	321	321	331	302	302	302	302	255	269
2.	248	248	241	241	241	248	241	241	241	235	230
3.	269	262	262	262	269	262	262	255	255	255	248

FIG. 14 CHART SHOWING RESULTS OF TESTS ON SORBITIC AND NON-SORBITIC STEEL RAILWAY-WHEEL TIRES

TESTING AND MEASUREMENTS (See also Measuring Apparatus)

Measurement of Pulsating Flow by Nozzles

THE USE OF NOZZLES IN MEASURING PULSATING FLOW. When nozzles are used for measuring pulsating flow, errors result unless the flow curve is known as a function of time. In the testing or regular supervision of the air delivery of reciprocating compressors, it is quite possible to install a large tank between the compressor

and the delivery line. This tank may well act as an aftercooler for removing the moisture from the air. If this tank be about three or four times the volume of the high-pressure cylinder, the flow fluctuations are greatly reduced. If in addition a throttling flange be applied at the end of the tank, i.e., at the place where the tank joins the delivery pipe—then the flow in the delivery pipe will be rendered quite even, and a nozzle or a similar instrument can be used with great accuracy. The larger the tank and the smaller the throttling flange, the more uniform is the flow. The flange need not be so small as to produce any noticeable pressure drop.

The same method can also be used in the application of steam meters to measure the flow of steam for reciprocating engines. Every engine should be equipped with a large receiver separator, and can in addition be equipped with a throttle flange at the place where the steam main joins the receiver separator. The flow is made even enough to apply a steam meter and to accept its readings without any correction.

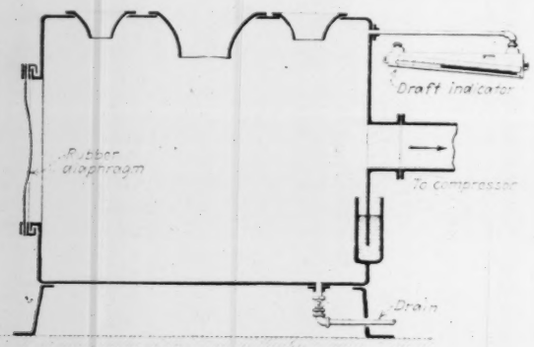


FIG. 15 USE OF NOZZLE ON INLET SIDE OF COMPRESSOR

It has also been suggested that the flow in lines carrying variable-velocity fluids can be made even for a distance by placing a fan in the line at either side of the nozzle or of the measuring instrument. The theory is that the fans have inertia and resist pulsating flow, thereby reducing the violence of the pulsations.

For the ordinary run of shop compressors, it is usually preferable to test the compressor while in operation. This can be done by using nozzles on the inlet side, provided, of course, that the piston-rod packings are tight. In this case it is quite easy to obtain uniform flow by attaching to the compressor inlet a sheet-iron box which carries the nozzle or nozzles, and which in addition is equipped with a rubber diaphragm as shown in Fig. 15. The volume of the box acts as an equalizer, and the rubber diaphragm which flops in and out helps materially to maintain an almost constant flow through the nozzles. A box of this kind is a very valuable adjunct to mechanical laboratories and especially to shops in which air compressors are built or used, because it allows testing of the actual air-compressor delivery with very little trouble. To this end it is advisable to have several nozzles in the box and to plug up those not in use.

It is very desirable to have a safety valve on the box to protect the rubber diaphragm from injury in case some one should close more nozzles than is good for the rubber. Such a safety valve is indicated on the right-hand side of the box in the shape of a U-tube full of water. The section of the U-tube must be large enough to prevent the formation of such a vacuum in the box as might break the rubber diaphragm. The pressure drop of the nozzles can be kept quite small, and can be measured by means of an inclined gage, such as a draft gage. The pressure drop through the nozzles amounts to much less than the variation in barometric pressure, and no fear need exist that the measuring box will interfere in any way with the air delivery of the compressor.

Nozzles have not been used for testing to the extent they deserve, probably because of lack of standard nozzles on the market. However, these are now available. Occasionally it is practically impossible to dampen the vibrations on account of the size of the equipment—for instance, to the air inlet of blast-furnace blowing engines. In that case the flow-velocity curve can be determined occasionally by placing in the nozzle a very light flapper and by recording its motion on the indicator. (*Chemical and Metallurgical Engineering*, vol. 26, no. 1, Jan. 4, 1922, pp. 32–34, 3 figs., *dp*)

TRANSPORTATION (See Railroad Engineering)

VARIA

CHEMICAL RESEARCH IN GERMANY. In connection with the story of the development of a process for the manufacture of synthetic gold in Germany, given wide circulation by the public utterances of Prof. Irving Fisher, *The Chemical Age* quotes the information of authorities who have made personal inquiry into the matter that important progress has been made during and since the war in agricultural chemistry in Germany.

It is said that processes have been developed of treating seed both to protect it from pests and disease, and to increase its vigor enormously. The idea, in short, has been by new chemical processes of fertilization to impregnate the seed with energy which has hitherto been applied externally at later stages of growth. How far this is true we are not in a position to say, but it is confidently asserted that as the result of experiments, seed so treated is rendered far more immune from disease and pests, that the plant life is fed with far greater effect and becomes proportionately more vigorous, and that the yield is largely increased. All this, like the story of synthetic gold, has to be proved in practice, but it is enough to convince us that German research chemists, instead of resting content with past achievements, are working for further advances and eagerly searching after new starting points. (*The Chemical Age*, vol. 5, no. 132, Dec. 24, 1921, p. 788, *g*)

WAGES IN GERMAN MACHINE INDUSTRIES. Table 1 shows a comparison of hourly wages paid in the machine-building industry in Chemnitz, Germany, previous to the war and since Jan. 1, 1922. In the present agreement on wages of workers in the metal industries a basic hourly rate is fixed, and the worker receives a certain

TABLE 1 COMPARISON OF WAGES IN MACHINE BUILDING INDUSTRY

Class of Worker	Age	Marks	1922 Dollars, Present Exchange	Marks	1914 Dollars, 1914 Exchange
Toolmakers	over 25	11.20	0.07	0.60	0.15
Patternmakers	21–25	9.85	0.06	0.60	0.15
Molders, (Highly	19–21	8.50	0.05	0.60	0.15
Skilled Operators)	17–19	6.29	0.04	0.60	0.15
Machine Operators	over 25	9.50	0.06	0.50	0.125
	21–25	8.25	0.05	0.50	0.125
	19–21	7.00	0.04	0.50	0.125
	17–19	5.05	0.03	0.50	0.125
Unskilled Labor	over 25	9.30	0.06	0.40	0.10
	21–25	8.15	0.05	0.40	0.10
	19–21	6.80	0.04	0.40	0.10
	17–19	4.75	0.03	0.40	0.10

additional rate on account of the high cost of living. In the table these two items are added together. Furthermore, skilled workmen who are always employed at an hourly rate (not on piece work) receive an additional amount which has also been included in the figures given. In figuring present exchange, one mark has been assumed to be equal to 0.6 cent. (*Machinery*, vol. 28, no. 6, Feb., 1922, p. 453, *g*)

OVERHEAD CONVEYANCES. A new type of overhead conveying system has been placed on the market and it is claimed that its construction is such as to make it necessary to erect a superstructure from which to suspend the system. The track consists of two parallel rails which is said to minimize the possibility of the trolley jumping the track. The rails are laid on a plate to which the U-bolt hangars are bolted and are thus supported from the bottom instead of the top which is said to eliminate the danger of the rails becoming dislodged and dropping to the floor. To insure further the stability of the track a special rail section is used with the base wider on one side than on the other. By throwing the center of gravity of each rail towards the middle of the track, the possibility of the rails being forced out of position and turning outward is reduced. (*The Iron Age*, vol. 109, no. 6, Feb. 9, 1922, pp. 409–410, 5 figs., *md*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a resume of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Electrical Instruments A1-22. Capacity Effects in Induction Coils. A coil of wire wound in any of the familiar forms called *inductance coils* behaves in an electric circuit primarily as an inductance. The potentials of the different parts of the coil are, however, different from each other and from the potential of the ground. For this reason the coil also behaves to a certain extent as an electric condenser, or rather a system of condensers. These capacity effects of inductance coils are particularly important at the high frequencies employed in radio communication. The effective capacity of an inductance coil depends in general both on the capacities existing between parts of the coil itself and on the capacities existing between parts of the coil and the ground.

On account of the importance in radio communication of capacity effects in inductance coils, careful studies of these effects, both theoretical and experimental, have been made at the Bureau of Standards. An interesting result which has been found is that one effect seems to depend primarily on the capacity of the coil to ground. This effect is observed when two condensers in series are connected across the terminals of the inductance coil, and the common terminal of the two condensers is grounded. If the inductance coil possesses capacity to ground, the familiar criterion for resonance in the system, computed from the known value of the capacities of the two condensers, will not apply.

If both condensers are variable and the system is adjusted for resonance by successively assigning arbitrary values for the setting of one condenser and then tuning with the other condenser, it would be expected from elementary considerations, neglecting the effects of distributed capacity, that the successive resonance values of the capacity of the two condensers in series, determined as the product of their capacities divided by their sum, would be constant. On account of the distributed capacities this simple relation does not hold. It is found, however, that under the conditions above mentioned, with the common terminal grounded, the capacity of the two condensers in series determined as the product of their capacities divided by their sum, is linearly related to the reciprocal of the sum of their capacities. This relation has been verified both mathematically and experimentally.

The results of both the mathematical and experimental investigation of this particular phase of the problem of capacity effects in inductance coils are given in Scientific Paper No. 427, entitled "Some Effects of the Distributed Capacity between Inductance Coils and the Ground," which has just been issued by the Bureau of Standards. Copies may be purchased from the Superintendent of Documents at 5 cents a copy.

Fuels, Gas, Tar and Coke A5-22. Lignite Carbonization. One of the recent reports of the Bureau of Mines is that on Lignite Carbonization and Carbonized Residue Briquets by W. W. Odell, Fuel Engineer. In his introduction the author states that "the development and utilization of low-grade fuels is not new, but on this continent conditions have not heretofore been favorable to such enterprises. The abundance of the available supply of lignite in this country in locations where other fuel is only obtainable by a long freight haul from distant sources, has made the 'lignite problem' a serious one for domestic consumers in such localities as North and South Dakota and Texas."

The plan of the work was to carbonize approximately 1000 tons of raw lignite by continuous operation of the carbonizer, briquetting the residue into a firm, solid fuel, and to obtain meanwhile as much data as possible relating to the following: (1) Quality and quantity of gas obtained, (2) quantity of gas required for carbonizing, (3) behavior of lignite during processing, (4) capacity of carbonizer, (5) quality and quantity of residue obtained under various conditions, (6) analyses of lignite, residue and the briquets made therefrom, (7) binder requisites, (8) character of briquets made, (9) control methods, (10) cost of briquetted residue, (11) quantity of by-products, and (12) design of apparatus suitable for carbonizing lignite. Address Bureau of Mines, Washington, D. C., H. Foster Bain, Director.

Fuels, Gas, Tar and Coke A7-22. Alcohol for Power. The Fuel Research Board of the British Department of Scientific and Industrial Research have prepared for distribution the Second Memorandum on Fuel for Motor Transport. This report gives a brief general survey of the work of the Fuel Research Board with regard to Power Alcohol since July, 1920, the date of the publication by H. M. Stationery Office of the Board's Interim Memorandum on Fuel for Motor Transport."

The subject is dealt with under the following heads: (*a*) Raw Materials, (*b*) Experimental Cultivation of Jerusalem Artichokes and Sugar Mangolds, (*c*) Molasses as a Raw Material, (*d*) Production of Alcohol in the British Dominions and Colonies, (*e*) Synthetic Production, (*f*) Production from Cellulosic Materials, (*g*) Legislation, (*h*) Denaturing, (*i*) Experimental Work on Utilization, (*j*) General Conclusions. Address H. M. Stationery Office, 28 Abingdon Street, London, S. W. 1. Price including postage 7½d.

Gases, General A1-22. Gas Cylinders. The British Department of Scientific and Industrial Research has just issued the first report of its Gas Cylinders Research Committee. This report, which consists of a majority and a minority report, gives the conclusions and recommendations of the Gas Cylinders Research Committee on the types of gas cylinders which should be employed for the storage and transport of compressed gases which are not in the liquid state in the cylinder.

Appendices to the Report include full reports on tests made at the National Physical Laboratory on cylinders of high-carbon steel subjected to varying heat treatments and on very light steel cylinders made for the Royal Air Force during the war, a summary of the evidence given by witnesses before the Committee, a summary of the regulations governing the use and transport of cylinders in Great Britain, France, Germany, and the United States of America, and a note on the deviations of technical gases from Boyle's Law. Address H. M. Stationery Office, 28 Abingdon Street, London, S. W. 1. Price including postage 7s. 9d.

Heat A2-22. Thermal Stresses in Steel Car Wheels. For some time the Bureau of Standards has been accumulating data obtained in thermal tests of car wheels. So far the tests on 16 wheels have been completed and it is possible to summarize the interesting features of this data as follows:

1 None of the steel wheels failed.

2 Because of the movement of the hub with respect to the rim, on account of the heating of the rim, a beam effect is produced in the plate which induces tensional stresses near the hub and stresses in compression near the rim on the face of the plate, while on the back of the plate the stresses are approximately equal in magnitude but reverse in nature.

3 These effects were observed in new wheels, while in the case of old wheels the stresses on the face of the plate were in tension near the hub and at the rim they decrease to practically nothing, this difference from the new wheel probably being due to the quantity of metal worn away.

4 The magnitude of the maximum stresses developed approximated the yield point of the material as determined in tensile tests.

5 After the first "run" on the new wheels, an apparent set was obtained which was not the case in succeeding "runs" nor in "runs" on old wheels. The maximum stresses were in the surface of the plates and beyond the yield point of the material.

Further work on single-plate chilled-iron wheels seems justified in view of the fact that a survey of the stresses on the back of the plate of this type of wheel was not made. From experience with the steel wheels, it is believed that the stresses will be quite different from those on the face. Address Dr. S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Lignite A1-22. Lignite Carbonization. See *Fuels, Gas, Tar and Coke A5-22.*

Petroleum, Asphalt and Wood Products A2-22. Specific Heats and Heats of Vaporization of Motor Fuels. In a paper read before the American Chemical Society Messrs. Robert E. Wilson and D. P. Barnard, 4th, present the results of a series of observations on the total sensible heats of completely vaporized motor fuels. These, combined with critically compiled data from the literature on heats of vaporization of motor fuels, make it possible to draw accurate total-heat curves over the whole range of temperatures up to 500 deg. cent. and derive fairly accurate values for the specific heats of the hydrocarbon vapors. Combinations of these with vapor-pressure data make it possible to determine just how hot the air or the fuel must be preheated in order to completely vaporize the motor fuel in a carburetor. Address Charles L. Parsons, Secretary, American Chemical Society, P. O. Box 1505, Washington, D. C.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for cooperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Electric Power B1-22. Design of Electrical Machinery and Lines. During the present year Prof. V. Karapetoff is carrying on an investigation on mechanical aids in the design of electrical machinery and lines. He expects also to make a study of fields of force or flow, electric,

magnetic and hydraulic. Address Professor Karapetoff at Cornell University, Ithaca, New York.

Highways B1-22. Traction Dynamometer. See *Transportation B1-22.*

Machine Tools B1-22. Cutting Tests of High-Speed Tool-Steel Bits. See *Steel, Its Treatment and Products B1-22.*

Steel, Its Treatment and Products B1-22. Cutting Tests of High-Speed Tool-Steel Bits. A number of tool bits of standard high-speed tool steel have been heat-treated in various ways by the Bureau of Standards to determine the effect of these treatments on the cutting qualities of the metal. About 55 cutting tests were made, and while no new facts were brought to light, the data obtained were interesting and show that it is possible to obtain valuable results from tests made with such small samples. This work is being continued, and an effort will be made to study the time temperature relations in preheating and hardening on the cutting qualities of high-speed tool steels. Address Dr. S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Transportation B1-22. Traction Dynamometer. Prof. F. L. Fairbanks is now developing and completing at Cornell University a traction dynamometer of considerable interest.

Ventilation B1-22. Infiltration of Air. A study of the infiltration of air into buildings through walls and windows is one of three problems which Prof. H. Diederichs has taken up this year. The other two are (*a*) satisfactory heat treatment of "Kinite" alloy steel and (*b*) the combustion process in a Diesel engine.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories.

Available Equipment. In a letter just received from Assoc. Prof. William J. Dana of the Mechanical Engineering Department of North Carolina State College of Agriculture and Engineering, it is stated that owing probably to its distance from a large industrial center the facilities of the mechanical laboratory of this college, though well equipped, are not being taken advantage of. They have all the usual small apparatus, such as the Emerson bomb calorimeter, the Saybolt viscosimeter, the Sargent improved gas calorimeter, etc. Their power plant and equipment include six boilers, hand-fired, steam engines, small steam turbines, an 11-hp. Foos engine and other gas and oil engines of various sizes.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the office of the Society.

Petroleum and Allied Substances. Under the title Recent Articles on Petroleum and Allied Substances, Mr. E. H. Burroughs, Bibliographer of the Bureau of Mines, has compiled a valuable bibliography of interest to all those in any way connected with the petroleum industry. This report is known by Serial No. 2305 and may be obtained by addressing H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this Journal, and brief articles of current interest to mechanical engineers.

Advantage of Nitrogen in the Boiler Furnace

To the Editor:

Referring to the short article on the Advantage of Nitrogen in Boiler Furnaces, published on page 802 of the December issue of Mechanical Engineering and credited to *Power*, I would say that the logic of it is all wrong. To carry the author's course of reasoning further, why not run with large quantities of excess air and buy coal with the largest possible amount of ash so as to lower the furnace temperatures to the greatest possible extent?

The use of oxygen or enriched air promises paying results in blast furnaces or open hearths, etc., because the working temperature of the furnace is so high that normally most of the heat generated passes off in the products of combustion, and any method by which the volume of these and their heat control may be materially reduced will have an enormous effect on the efficiency and fuel consumption of these furnaces. Boilers, on the other hand, can utilize heat down to very low temperatures by the use of economizers so that the possible fuel saving is much less, and the cost and complication of the apparatus for supplying oxygen would have to be reduced correspondingly to make it commercially attractive.

From a purely operating point of view, however, the problem of boiler adaptation is simpler than maintaining a roof in an open hearth at any higher than present temperatures, though these can be controlled and practically the same efficiency of the process obtained by arranging the mixture of fuel and oxygen so that this and the combustion are progressive and the heat is absorbed as fast as it is generated, resulting in temperatures not exceeding a safe limit but with all the heat generated at a high enough temperature to be effective.

I have seen a boiler with a little over 10,000 sq. ft. of heating surface evaporate over 150,000 lb. of water per hour for 3 hours on oil fuel, so that no anxiety need be felt regarding the heat absorption of the water-cooled surfaces.

Material arguments controverting those in the article in question appeared over the writer's signature in the issue of *Power* for November 22, 1921.

New Haven, Conn. H. D. Fisher.

Novel Pumping Plant in Operation at Key Biscayne, Florida

To the Editor:

A rather unique pumping plant has been placed in operation at Key Biscayne, Miami, Florida. The accompanying snap shots show the installation of an overshot water wheel to take the flow from an artesian well. This wheel, 12 feet in diameter and turning at 7 r.p.m., is geared to a duplex pump operating at 40 strokes per minute which is used to pump water from the well drainage

Overshot Wheel Driving Duplex Pump

sump well into an elevated storage tank. This tank supplies water for irrigating a nursery and also for homes on the island.

The water from the well is very strong in sulphur and comes from a depth of approximately 1,000 feet. Tests give the rate of flow at an elevation of 12.92 feet as 248 gallons per minute which provides 0.82 hp. for operating the wheel. 0.46 hp. is utilized in pumping the water which gives an overall efficiency on the plant of 56.8 per cent.

Miami, Florida. Welton A. Snow.

Standardization in Japan and Norway

Standardization work in Japan has recently been given a great impetus by the organization of the Japanese Engineering Standards Committee. The main function of this Committee is to serve as a bureau for solving and initiating problems involving engineering standardization. The Committee consists of 70 members presided over by the Minister of the Department of Agriculture and Commerce acting as president, and a vice-president, who is elected or appointed. The details of the work are handled by seven secretaries who are engineers of the government departments of Agriculture and Commerce, Communications, Railways, Military Engineers and Naval Engineers. The work is being pushed with vigor, investigations already being under way on metals, woods, bricks, screws, electric wires and electric motors.

In Norway a national standardization committee has been organized by the Federation of Norwegian Industries. One of the first projects which is being taken up by the new committee, after the necessary work on organizational problems, is the standardization of ship machinery and ship details.

There are now national standardizing bodies in the following fourteen countries: Austria, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Holland, Italy, Japan, Norway, Sweden, Switzerland and the United States.

International Cooperation in Standardization

A.E.S.C. Sales Agent for Foreign Standards. The American Engineering Committee has just completed arrangements by which cooperation with the standardizing bodies in other countries will be made more effective. In doing this it has followed out the recommendations of the Unofficial Conference of the Secretaries of the National Standardizing Bodies held in London in April, 1921.

In order that all standards shall be available to the industries of the various countries, it is planned that each national body will sell the approved standards of the other bodies. The American Engineering Standards Committee, 29 West 39th St., New York City, has available now the publications of the standardizing bodies in Austria, Belgium, Canada, France, Germany, Great Britain, Holland, Sweden and Switzerland.

Hereafter the A.E.S.C. will regularly exchange information with the foreign bodies as to the status of work on the various projects being undertaken under its auspices. This information will be limited to the indication of the stage of development of the projects, it being left in each case to the various sectional committees and sponsor bodies to decide to what extent they desire to exchange technical memoranda or drafts of standards. This exchange of information on the general progress of the work will, however, lay the basis for closer international cooperation as the need for this develops in special instances.

A.S.M.E. Transactions Index Contemplated

Pressure has been exerted on the Society to compile and issue a comprehensive index of Transactions to date. Such a book will render available the exceedingly valuable information contained in Transactions, and the Committee on Publication and Papers has the project under advisement, pending an expression of opinion from the Society. The acknowledgment card, which is sent out with volume forty-two of Transactions, will permit a statement of each member's desires in the matter of this index, and if sufficient orders are received the book will be issued some time during the fall. It will be bound in half morocco, uniform with Transactions. Price will depend somewhat on the number of copies ordered, but it is believed that it will not exceed $4.00.

A Correction in Machine-Shop Discussion

Professor John Airey has called our attention to an error in the report of his closure to the discussion on the paper entitled Art of Milling by John Airey and Carl I. Oxford. At the bottom of page 16 of the January issue of MECHANICAL ENGINEERING mention is made of "machine belt." This should have read "machine ability tests." The shortness of time alloted to the discussion of this paper did not permit a proper closure by Professor Airey. This will be included in TRANSACTIONS.

STANDARDIZATION, AMERICAN INDUSTRY AND THE FEDERAL GOVERNMENT

(*Continued from page 186*)

not to deal with technical details has proved a source of great strength in its real work of insuring the full coöperation of organizations producing standards not in conflict.

AN EXAMPLE OF FUNCTIONING OF THE A.E.S.C.

In determining the desirability of undertaking the development of a proposed standard, it has proved highly satisfactory to initiate the movement by calling a conference of the bodies interested, which the A.E.S.C. does upon request from a responsible organization or organizations.

As an example of such a conference, mention may well be made of the Conference on the Standardization of Railroad Ties held in Washington, D. C., in October, 1921, at the joint request of the Forest Service and the American Railway Engineering Association. Invitations to this Conference were issued to the several national organizations representing not only producers and consumers but also general interests, the last mentioned being the American Society of Civil Engineers, the American Society for Testing Materials, the Department of Commerce, and the Forest Service. The official representatives of the organizations were asked to decide: (1) whether the unification of specifications for railway cross-ties and switch ties should be undertaken; (2) if so, what the scope of the work should be; and (3) how the work should be organized.

After a very full discussion of all phases of the important problem before it, this Conference reached a unanimous agreement on all points under consideration. It recommended that the Forest Service and the A.E.R.A. be designated as joint sponsors for a "Sectional Committee" to unify railway-tie specifications under the Rules of Procedure and auspices of the A.E.S.C., and recommended to the sponsors that certain specified national organizations be invited to be represented officially on the sectional committee. Although it might seem apparent, without discussion, that the unification of railway-tie specifications should be undertaken, the subject was discussed for two hours before the Conference was asked to place itself on record on this matter, which it did by unanimous vote. All of this discussion was beneficial in paving the way for the discussion of the scope of the work and the organization therefor.

A conference called as this conference was called and conducted as this conference was conducted results in a spirit of coöperation that cannot otherwise be brought into existence. The plans laid down for carrying out the work of standardization will insure that the coöperative spirit brought into being by the conference will continue to be the controlling feature of the work of eliminating existing conflicting standards and "Americanizing" the standards that will be formulated hereafter.

Too much emphasis cannot be put upon the advantages of the conference method of initiating work on any particular standard or set of standards, provided the conference is truly representative. When men get together in such a conference, from an interchange of ideas they obtain a comprehensive view of the whole field; harmony emerges from discord and differences disappear in agreement.

ADVANTAGES OF NATIONAL STANDARDIZATION REITERATED

In closing, it cannot be too often repeated that a national standardization program means almost unlimited advantage to the manufacturer in cheapening the processes of production and stabilizing his market; to the distributor in clarifying and simplifying his problems; and to the ultimate consumer by lessening costs and expediting deliveries. The real significance of standardization to industry and the Federal Government—what it may mean and what it can accomplish, will not be fully realized until there is sincere coöperation which is sympathetic, systematic and comprehensive, between industry and the Federal Government, in which coöperation the general consumer has a part.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

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C 55 The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

Engineering Education—the Development of the Resourceful Mind

It may seem presumptuous for me to offer any observations upon the subject of engineering education. I feel prompted, however, to make the attempt, at least, because of the kindly urgent request of the Editor of this magazine and also because the end of education for the engineer is the same as for any other profession. This end in a word is the development of mind and of character. One who has a highly developed mental equipment without character is a menace to the community; one who has character without mind, however high may be his purpose and ambition, proves ineffectual in the contests and conflicts of life. Therefore, I affirm most emphatically that true education has for its object both the trained mind and the thoroughly trustworthy character.

JOHN GRIER HIBBEN

Owing to the limits of the space assigned me I shall confine my observations solely to the training of the mind, not wishing however, to leave the impression that I regard character as in any way of secondary significance.

The discipline of the mind depends more upon the methods of teaching than the subjects taught. In preparing for the career of an engineer, as for any other profession, it is indispensable for future success and conspicuous leadership that the student should be led to a firm grasping of fundamental principles rather than the mere accumulation of facts. The fundamental sciences, mathematics, physics and chemistry, must be mastered by every student of engineering. To acquire a knowledge of these sciences encyclopedic information is not adequate.

Many centuries ago Aristotle remarked that there are two types of mind, the one which acquaints itself with the facts of a subject, and the other which penetrates to the reasons underlying these facts. The latter, he adds, are the philosophic minds. By philosophic mind Aristotle meant what we today would characterize as the scientific mind.

The true engineer must be the scientific engineer, that is, the one acquainted with the great fundamental principles of the underlying sciences of his profession and who early acquires the habit of asking the question Why, and searching for the answer with eagerness of spirit as for a hidden treasure.

Many years ago one of our graduates in engineering started a career in the West of very brilliant promise, brought to an end with only partial achievement by a fatal accident in the prosecution of his duties. Upon one occasion I met him in Princeton and I asked him what in his opinion was the most valuable characteristic of a successful engineer. After a moment's thought he responded, "The most successful engineer is the man who does not lose his head when face to face with an entirely novel situation." This gives the gist of the whole matter. To learn a rule easily applicable to familiar conditions and to apply the same with facility calls for a mind of intelligence, of course, but one acting only on the low level of routine. But to encounter a problem not familiar because disguised by entirely new conditions, to penetrate to the heart of the difficulty, to seize upon the possibility of applying some fundamental principle of mechanics, or of mathematical law, and to devise a method of procedure which will attain the desired result, this requires the talent of the truly scientific mind.

Throughout the whole of the training of the engineer there must be the supreme objective held in view by the teacher and by the student alike, namely, the development of the resourceful mind. That is the reason why I feel that an engineering education should produce first of all the engineer as such, rather than the engineer in any particular phase of his profession, such as that of the civil, the mechanical, the electrical, the chemical or the mining engineer. I imagine that the difficult problems which come to the engineer, however highly specialized his work may be, can never be dealt with satisfactorily by a knowledge only of his specialty. A problem in mechanical engineering may require the mechanical engineer to make his excursion into neighboring fields for the solution of the problem.

No method in education moreover, is satisfactory which appeals solely, or in a large measure, to the memory. The point of attack must always be the reasoning powers of the student, not only that, but there must be in the schedule of his studies and in the method of teaching a constant stimulation also of his powers of imagination. I do not refer to the unlicensed ranging of his fancy in fields foreign to his subject, but I do insist upon the mind being quickened in the solution of any problem by the discernment of all the possibilities of solution which may be dictated by the reason. We often think that the function and scope of the imagination are the natural activities solely of the artistic temperment, but there is a type of imagination which is essentially the function of the reasoning powers of man.

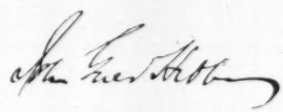
When an unfamiliar situation develops in any engineering enterprise and which stands as a stubborn obstacle in the way of progress it is the mind possessing imaginative skill which immediately brings before its scrutiny the complete array of possibilities of explaining the fundamental reason for the obstacle in question, and that in itself suggesting a proper method of overcoming it.

There is another phase in the career of the engineer which he has in common with all men whose work is to possess some permanent value for his day and generation. He must be able to deal successfully with the human elements in his problem as well as the material. General Goethals said of his great engineering enterprise in Panama, that the great difficulty of his work was the human problem. There must be, therefore, in the engineering studies not only the laying deep of the foundations of the fundamental principles of the great sciences, but there must be a like fundamental knowledge of human nature in its manifestations, both of the past and of the present.

I appreciate the fact that the secret of dealing wisely with men, gaining their confidence, understanding their weakness and their strength, creating among them a spirit of coöperation and even of willing sacrifice—all these are essential to the success of an engineer and cannot be adequately learned from textbooks or from lectures. It is the result of an experience gradually gained in the school of the world. But humanistic studies do tend, in some slight measure at least, to create the spirit of human understanding and of human sympathy, and that advantage (and I believe it is a real advantage), may be gained from them, and should not be

withheld from the prospective engineer. To learn something of the great masters of the world in philosophy, in art, in literature and in the guiding of national destinies, gives him not only a realizing sense of the secret of human power and attainment but suggests to him also the secret of how to make actual the potential energy that is always to be found in groups of men with whom he will have to deal, whether they be laborers, soldiers, or the directors and stockholders and colleagues in some great engineering enterprise.

The engineer who compels the forces of nature and the powers of man to conspire to do his bidding, who brings to his task, whether great or small, a creative spirit, who regards obstacles as a challenge gladly welcomed, and who has the courage to attempt that which to men of restricted vision seems impossible, such is the one who not only attains success as an engineer but is capable of contributing richly to the advancement of knowledge.



Autogenous Welding and the Unfired Pressure Vessel Code

The scope of the proposed code for the safe construction of unfired pressure vessels is far greater than was at first anticipated by the Boiler Code Committee of the A.S.M.E. which is now formulating this code to supplement its rules for the construction of steam boilers.

The demands from the state and municipal authorities for a code covering unfired pressure vessels have been insistent and the Boiler Code Committee has, as a result, been at work for over two years on this supplementary code. In this endeavor, however, it has been a difficult matter to adequately provide for all types and classes of pressure vessel construction and the fact that autogenous welding has been widely introduced for the construction of the joints of such pressure vessels has materially complicated the situation.

As the most recent development in this work, the Boiler Code Committee held a hearing on Monday, December 5, during the A.S.M.E. Annual Meeting, for those who were interested in the manufacture or use of unfired pressure vessels, to consider and discuss the proposed code for unfired pressure vessels, of which a preliminary draft was issued previous to the meeting. This pamphlet was the result of over two years of investigation and conference with allied organizations, and in it there was presented a constructive suggestion for this long-desired code.

The results of the investigations of the Sub-Committee on Welding were shown in the form of proposed specifications for autogenous welding, forge welding and brazing. While there was an attempt to render the code comprehensive, still every detail of either the construction requirements or the various specifications on which there had been lack of agreement were omitted and fourteen questions were listed for discussion at the end of the report.

This preliminary report had been distributed to nearly 500 individuals and concerns known to be interested in the manufacture or use of unfired pressure vessels considerably in advance of the meeting. The result was a large attendance at the hearing during both forenoon and afternoon sessions.

The preliminary draft of the proposed code was read paragraph by paragraph and discussion invited on each. The responses to the fourteen questions at the end of the report furnished the committee with much constructive data for use in shaping the proposed code into final form.

The committee finds that one of the major problems involved is the question of the use of autogenous welding and every endeavor will now be made to bring out the greatest possible amount of information concerning this form of welding in its relation to pressure vessel construction. To this end the A.S.M.E. Meetings Committee, the American Welding Society and the Boiler Code Committee are planning a special welding session at the coming Spring meeting of the Society to be held in Atlanta, Ga., May 8-11. It is expected that a number of welding experts who have carried on extensive research in this field will report there.

Charles Russ Richards Elected President of Lehigh University

Charles Russ Richards, at present Dean of the College of Engineering of the University of Illinois and Director of the Engineering Experiment Station, was elected President of Lehigh University at a meeting of the Trustees held February 7.

Dean Richards was born at Clarks Hill, Ind., on March 23, 1871. He was graduated from Purdue University with the degree of Bachelor of Mechanical Engineering in 1890 and a year later received the degree of Mechanical Engineer at the same Institution. In 1895 he obtained his Master's degree in mechanical engineering from Cornell University and in 1920 the University of Nebraska conferred on him the degree of Doctor of Science.

He was instructor in mechanical engineering at the Colorado Agricultural College during the year 1891-92. From 1892 to 1911 he taught at the University of Nebraska holding successively the positions of Adjunct Professor of Manual Training, Professor of Practical Mechanics, Professor of Mechanical Engineering, Associate Dean of the Industrial College, and Dean of the College of Engineering.

In 1911 he went to the University of Illinois where he has held in succession the positions of Professor of Mechanical Engineering,

CHARLES RUSS RICHARDS

Acting Dean of the College of Engineering and Director of the Engineering Experiment Station. In March, 1917, he was appointed to succeed Dean W. F. M. Goss.

At the University of Illinois, under the general direction of Dean Richards, the work in the college shops has been completely reorganized so that they have been converted into laboratories to provide instruction in the principles of industrial management in the art of manufacturing to illustrate the effect of the shop processes on the materials of instruction, and to do experimental and research work in connection with the cutting of metals and in the general field of engineering production. It is felt that the method employed in these laboratories constitute a distinct contribution to the field of engineering education.

Dean Richards has served as consulting engineer in connection with the power-plant and water-works problems and the appraisal of public utilities. He has been interested in engineering research relating to fuels, steam, air, and gas-power engineering.

He was elected to membership in the Society in 1892 and served as manager from 1918 to 1921. He is Chairman of the Power Test Codes Sub-Committee on Fuels. He also belongs to the Western Society of Engineers, Society for the Promotion of Engineering Education, Sigma Xi, Tau Beta Pi, Sigma Chi and Sigma Tau.

Herbert Hoover Emphasizes Duty of Engineers in Reestablishing Economic Balance

In Address at Annual Meeting of the American Engineering Council, Secretary of Commerce Indicates the Responsibilities of the Profession and Suggests Steps Toward Fulfillment

THE first Annual Meeting of the American Engineering Council was held in Washington, D. C., on January 5 and 6. An account of the proceedings of this meeting was included in the January 7 issue of *A.S.M.E. News*. The delegates to the Council gathered with the engineers of Washington at dinner on Thursday evening, January 5 and were addressed by Herbert Hoover, past-president American Engineering Council, Dr. Bedrich Stepanek, Minister from the Czecho-Slovakian Republic and John Temple Graves, journalist. Mr. Hoover's address inspired the subsequent deliberations of the Council by his call to the engineering profession for greater service. We are giving his remarks in full.

Fellow engineers: I did not come prepared with any large and efficient words of wisdom and have been rather fearful that I did not sit down in council with your directors and develop someting.

I am interested in this association not only because I participated—I do not put it higher—in the organization of the Council, but because this body has entered upon a path of public service that is unique in the whole United States. I have perhaps said before in urging some of our brother societies to join with the Council, that the engineer has developed himself all these years to the upbuilding of the material values of the United States He has done that effectively—more effectively than has been accomplished in any other of the great countries of the world. The birth of this society marks the evolution of the engineer into an interest in public affairs. With his intelligence, his experience and training and the unique knowledge that he possesses not only of the material but the intangible values amongst our people, he is now organized so that his united voice may become heard outside of his profession. We have probably 175,000 engineers in our country, representing an intellectual possibility for service possessed by no other group. It is therefore an augury of real social development when the engineers of the United States join together for purposes of public service.

This association has the unique value among the associations that it cannot have any material interest for its purpose. No engineer can receive any material benefit from it. It can advance no economic interest. It cannot therefore be charged with any ulterior motive. It is accepted by the whole American people who have become acquainted with its objectives as being clearly single-minded.

During the last year we considered a number of the problems that confront the American people in the light of what services the engineers could perform in their solution. We resolved early in the progress of the Council to undertake an investigation into the elimination of waste—a problem with which the engineer alone was fitted to deal, a problem that had not come in for solution outside of engineering circles. As a result of the investigation carried on during the past year and of the report made, there has been an enormous expansion of the consideration of these fundamental questions—questions that enter into the whole problem of the standard of living of our people. At the time we undertook that investigation we were still at the height of a boom. The country was going on recklessly spending, with extravagance and over-expansion. Almost every engineer, in consideration of the economic situation of the time and the early meetings of the Council, wondered when it would all come to an end and appreciated the waste that came from the operation of the business cycle, which reaches its peak in booms like that then affecting the country. That investigation resulted in a final report in the midst of the depression that was inevitable. It came just at a time when the country was receptive for ideas that in the long run must mean the correction of these tremendous losses from over-expansion and from depression.

On taking this position that I now hold I had felt that it was the duty of the Government, if it was possible, to carry into effect some of the purposes outlined by the Council. We have in the Department of Commerce, accordingly, established a number of agencies intended to effect the results outlined as possible. And in getting further knowledge and experience with this problem I am indeed impressed with the fact that it is the most fundamental of all of the economic problems with which the American people must deal. It becomes doubly important now because we are faced with certain primary conditions that cannot, in my view, receive any solution except along the lines laid down in that report on the elimination of waste.

If we take the year 1913 as a base year for economic calculation and assume that the price of goods to the producer was 100 and likewise the cost to the consumer was 100, and if we then examine the situation today we will find that in many, in fact the majority of cases, the value of commodities is not far from 100 in their return to the producer and, more particularly, we will find the agricultural products often far below that level. But, on the other hand, to the consumer, the price level is, in the majority of cases, from 150 to 170. We have, therefore, a tremendous distortion. That distortion bears heavily on the producer and the consumer. One or the other of the two must carry the brunt of that load. And if we are to decrease that margin, it can only be through the elimination of waste.

We have to bear in mind that during these last seven years we have probably added eight billions per annum to national, state, and municipal taxation. If, on the basis of the present value of the dollar, we estimate that the national productivity of the country is somewhere near fifty billions, it is possible to calculate at once that taxation alone accounts for at least twenty units out of the sixty or seventy with which we have to deal.

There are other elements that have entered into the problem—increased cost of transportation and a thousand direct or indirect increases in the cost of manufacture or distribution.

And, clearly, unless we can bring the cost of commodities to the consumer more nearly into line with the return to the producer, we shall indeed, to go no further, reduce our agricultural population to the status of the European peasant.

That is a problem of manufacture, transportation, and distribution. The distortion is not due to undue profits at the present time. It is distortion that can be corrected only through the elimination of wastes in our processes of distribution and other phases—transportation, business methods manufacture, and so on. Indeed the question of the elimination of waste entered into two years ago because of those glaring, outstanding instances that challenged every engineer now looms in the mind of every economist as the real hope of reestablishing economic balance in the United States.

We have enlarged our vision as to what constitutes waste. We are suffering today from one of the most fearful wastes that can come to us in that we have from two to three millions of idle men. Lost labor once over the dam is lost for all time. Any inquiry into the causes of our vast unemployment brings us at once to consideration not alone of the world as a whole and of our own economic cycle in relation to it but also to the problem of how to avoid such periods of waste.

Now, the engineers have rightly pointed out that there are times when we make large increases both in the direction of plant and equipment and production of consumable commodities; that if we are to correct and alleviate the intensity of our business cycles, we must find some method by which we can expand our plants and equipment at periods when the demand for consumable goods has relaxed. Nor is that a misconception. For if we were to hold over a part of our seasonal operations on great public utilities and public works through periods of from seven to ten years, a reserve of probably no more than ten per cent stored up for periods of depression in the production of consumable goods would enable us to maintain an even tenor and to secure even production of all commodities. There lies one of the greatest wastes and it is in the anticipation of that waste that lies one of the great economic problems of the country.

There are many ramifications of the waste problem with which you are familiar—many, more familiar than I am. But there is one factor in the saving of waste that I believe the engineers might give further consideration to and perhaps more investigation. And that is the problem of a larger view in electrification.

We are all aware of the results obtained in the investigation of the superpower development of the Atlantic seaboard. Superpower is not impossible in many other sections of the country. We are indeed on the threshold of enlarging the distances of transmission. We have the possibility of reducing waste through a large phase of electrical development made during the past thirty years. The American people have no appreciation of the possible results and the added efficiency, productivity, safety and advance that could be obtained in the enlargement of our entire electrical equipment. And there is nobody that could give this problem such consideration and so illuminate it in the national sense as this Council could do. It indeed requires the services of every branch of engineers that compose the Council. With the possibility ahead of us of the development of some twelve to fifteen millions of horsepower, the consolidation of hundreds, even thousands of minor plants, the enormous savings to be made through the substitution of electrical power for steam—in that there is a probability of the greatest material saving of waste possible in any country in front of the American people.

Now, it is one thing to suggest a problem and another thing to suggest its solution. It is a far more difficult thing to state a problem in a fashion that people will understand and state its solution in a fashion that will carry conviction. But an association of this kind, ramifying as it does into the best intelligence of every single community of the United States, has the opportunity to develop popular conception of its ideas more effectively than any other group in the country.

Still, I am not attempting to outline to you the services that you can undertake, for you have on your docket a long list of matters which must be given study and advancement. Thus I understand that you have had before you some question in the matter of a publication. That subject was up when I participated in your deliberations. We recognize the necessity of cohesion among the engineers. The objectives of the Council can be phrased in the common language of the great visions of engineers in the direction of the services they can perform for their communities. And in the contact of engineers with the public life of the Nation there is no possibility of overlapping in the technical services of our member societies.

I realize that the financing of such a publication as some of our members contemplate is of extreme difficulty. Yet, when we entered upon the publication of the Report on Elimination of Waste, we faced an expenditure of

some forty or fifty thousand dollars, and found that there were enough men ready to aid in carrying the investigation through. I do not therefore assume that the necessary expenditure in this case is insuperable but I do believe that one of the strongest measures that can be taken by the Council in promoting the unity of its own membership and the cohesion that it will create is some form of a service journal. And it is not alone a problem for your directors that the engineers should be reported in the public councils of the Nation but it is a problem of inspiring the same attitude of mind amongst the engineers in every city, town, and village in the United States. There is no State or city or municipal government that does not need the advice of the Engineering Council. There is no problem either in Federal or State or municipal legislation that does not at some point touch upon material construction and therefore come within the purview of the engineer. So that while the Council here in Washington and in those centers where the directors can keep in contact with needs and the problems in hand do a great service, the same opportunity and the same need exist throughout the country. I know of no way of inspiring service except by contact. That service the country needs.

It needs the plans and the intelligence of its engineers—the men who have in the very nature of their work the inspiration and enthusiasm and yet are the greatest realists in the world—and they are the men who should be heard from.

For the services you have done during the past year is small measure of what can and will be accomplished by you, through the Council.

Following Mr. Hoover's remarks, Mr. Calvert Townley, vice-president of the American Engineering Council, presented him with the following resolutions:

WHEREAS, our first President, Herbert Hoover, has been appointed Secretary of Commerce in the Cabinet of the President of the United States and

WHEREAS, in consequence of his acceptance of this high public office, he deemed it necessary to tender his resignation as President of The Federated American Engineering Societies,

Be it therefore resolved by American Engineering Council, that we hereby record our appreciation of the rare judgment and vision with which Mr. Hoover has directed the initial policies of The Federated American Engineering Societies, and the ability and uniform courtesy with which he has presided over the deliberation of the Council and the Executive Board.

Be it further resolved that American Engineering Council acting through its Executive Board express to him the sincere regret with which his resignation has been accepted and its sincere good wishes for a continuation of that distinguished success which has followed him in his past services to this profession, his country and mankind.

In acknowledging the presentation, Mr. Hoover said:

Gentlemen, I very much appreciate this expression but I do feel that because I did not give the services to the American Engineering Council while I was its president that I should have given, the Council was the product of your four vice-presidents.

Any man likes to have such things, to treasure in his household, for they bring back recollections of the sweetest things in life.

And I accept them too, in view of the day when I shall have to return to the profession to earn my daily bread, when I shall need such a certificate of character.

So I shall have them framed, and have them ready for the engineer's office that stares me in the face. Nor would I be sorry to re-enter a profession whose sole passion is to build and to construct, for those indeed are the greatest privileges given to man.

I thank you.

American Welding Society Issues First Number of Proceedings

The first number of the Proceedings of the American Welding Society has just reached us. This publication will deal with the activities of the American Welding Society and its Research Department, which is organized as the American Bureau of Welding. Technical papers, research items and other notes of interest to those engaged in the art of welding will appear as well as news of the American Welding Society and its sections.

The American Welding Society is to be congratulated upon its enterprise in developing this medium of communication with its membership. Its form is readable, attractive and dignified.

Announcement of the DeLameter-Ericsson Tablet Committee

At the Commemoration meeting, December 3, 1919, fourteen organizations participated. Afterward it was decided to turn the money that was left over into a fund which would be increased sufficiently to erect bronze tablets on the sites of four buildings with which the lives and work of the two men who were being memorialized were identified. Seven more organizations then joined the movement and it was decided to assess each the sum of $250 and thus raise a fund of $5000 which amount was deemed necessary for the plan proposed. Some of these organizations have oversubscribed their quota, others have not met theirs. There is about $1000 still to be raised.

The following members of the A.S.M.E. subscribed the amounts specified:

H. R. TOWNE	$50.00
H. F. J. PORTER	11.00
J. W. LIEB	10.00
G. M. NEWCOMER	10.00
S. BEVIN	5.00
V. D. BEVIN	5.00
A. FALKENAU	5.00
D. S. JACOBUS	5.00
D. J. LEWIS, JR	5.00
ALEX SCHEIN	3.00
A. HOLLENDER	1.00

The Committee would welcome further subscriptions. Checks should be drawn to the DeLamater-Ericsson Tablet Committee and forwarded to the headquarters, 29 West 39th Street, New York, N. Y.

Any money remaining after the unveiling exercises on March 9 will be devoted to securing a permanent repository for Capt. Ericsson's models, medals and other memorabilia which are now widely scattered.

Engineering Study of the Pittsburgh District

The Carnegie Institute of Technology has undertaken an investigation of the Pittsburgh district to be carried out on an unusually broad and comprehensive scale. An area covered by a circle of 30 miles radius with the City of Pittsburgh as a center, is to be considered, and the investigation is to embrace power generation, finances, natural resources, transportation facilities, land and labor markets—all from an economic rather than a sociological point of view. It will differ in this way from the majority of previous similar investigations.

Since the fields covered are so diverse that no one individual could undertake such a study, the Carnegie Institute of Technology has alloted the power problem to its engineering departments, its economic department is working on the finances, the geological department on natural resources, etc., while the whole is under the general supervision of the commercial-engineering department.

The real value of such a study comes not so much from the individual reports, as from comparisons that it is possible to draw and the weighing of one report in terms of the others. For example: at the present time there are no means of telling whether the power, finances and transportation facilities in this district are properly balanced. The report as a whole will disclose such conditions, where they would not have been evident from the individual studies. It should also bring to light certain things regarding labor in its relation to investment and industry.

The Pittsburgh district particularly lends itself to such a survey, both because the industrial density is greater than in any district of equal area in the United States, and especially, for general power study, because certain large divisions of power having complete available records, can be separated with considerable accuracy.

In this connection it is surprising what interest has been manifested in this report. The two large electric power companies have worked together to get the data desired, and the steel and other manufacturers are giving figures that would otherwise be almost impossible to obtain. Data is being collected, not only for the present time, but extending back for a considerable period of years, so that the general industrial trend and growth and the effect of the war can be seen.

Some of the individual reports have progressed more than others, and may be published singly from time to time. One or two are nearing completion, but it will be some time before the complete report can be finished.

The Carnegie Institute of Technology states that they will welcome assistance and information that might help towards a more perfect execution of their important task.

The purpose of the investigation is heartily endorsed by Secretary of Commerce Hoover.

Engineering and Industrial Standardization

New Standardization Projects under the A.E.S.C.

Bolt, Nut and Rivet Proportions. During the past fifteen years or so a considerable number of standards for the external dimensions of bolts, nuts and rivets have been formulated by the societies and associations whose members are vitally interested. These standards are now to be reviewed by a Sectional Committee organized under the Rules of the A.E.S.C.

This Sectional Committee is being sponsored by the Society of Automotive Engineers and The American Society of Mechanical Engineers and the individuals and firms most directly connected with the activities of the former Nut, Bolt and Rivet Institute are lending every possible aid in the organization of the Committee. It is the desire of the Sponsors that every organization, which is in any way interested in this project, be represented on the Sectional Committee.

The board representation which this Committee will have, therefore, will insure the general acceptance of the standards which it will propose to the A.E.S.C. as American Standards. The results of its work, however, will have an international as well as a national significance, for the Swiss through their Commission de Normalisation du VSM of Switzerland have already inquired concerning the American Standard external dimensions of nuts and bolt heads of various kinds.

Safety Code for Compressed Air Machinery. The American Society of Safety Engineers and The American Society of Mechanical Engineers have been designated as sponsors for a Safety Code for Compressed Air Machinery by the American Engineering Standards Committee. The code will include rules for the construction and use of compressors, tanks, pipe lines, and the utilization apparatus where compressed air is the active agent. In accordance with the usual procedure, the code will be formulated by a Sectional Committee composed of representatives designated by the various bodies interested. This Sectional Committee is now being organized by the Sponsors who cordially invite suggestions for the personnel.

Census of Engineers and Others Engaged in Promoting Industrial Safety. All branches of the engineering profession will watch with close interest the results of the safety census now being taken by the National Safety Council. Many engineers are devoting their efforts entirely to safety engineering and practically all engineers have more or less to do with safety principles in their work and are interested in the subject. This census is intended to include, however, all persons engaged in safety and industrial health, and it is believed that this is the first time that any attempt has been made to list all the persons engaged in these activities professionally.

The information which the Council seeks includes (*a*) name and full address of the worker, (*b*) company or organization for which engaged, (*c*) nature of the company's business, (*d*) nature and extent of the present safety activity and (*e*) previous experience. By sending these data promptly to the National Safety Council, 168 N. Michigan Avenue, Chicago, those engaged in this line of work will help to make this census taking a success which will thereby assist the whole safety movement.

Standard Methods for Wood Testing. The American Society for Testing Materials and the United States Forest Service have been designated by the American Engineering Standards Committee as joint sponsors for the development of uniform standard methods of testing wood. This action was taken as the result of a canvass made of the principal national bodies concerned with the proposed project, from which it was apparent that there is a real demand for the work, and that the joint sponsorship here indicated would be acceptable to the industry.

Standardization of Railroad Ties. The American Railway Engineering Association and the U. S. Forest Service have been designated by the A.E.S.C. as joint sponsors for the unification of specifications for wood cross-ties and switch ties for all classes of use including mining ties. The work is to include the grouping of ties with regard to preservative treatment, but not methods of treatment; and inspection rules. This action is in accordance with the recommendations of a conference on railroad ties, to which the following organizations had designated representatives:

American Electric Railway Association
American Railway Engineering Association
American Society of Civil Engineers
American Society for Testing Materials
National Association of Railroad Tie Producers
National Hardwood Lumber Association
National Lumber Manufacturers Association
U. S. Department of Commerce
U. S. Forest Service.

For carrying out the work there will be organized by the sponsors a sectional committee having accredited representatives of the above organizations and of the American Mining Congress, and the American Wood Preservers Association.

A.E.S.C. Calls Conference on Overhead Wire Crossing Specifications

At the request of the American Electric Railway Association, a conference is being called by the American Engineering Standards Committee to decide whether there shall be uniform specifications for the crossing of overhead wires, and to dispose, if possible, of certain differences of opinion in regard to those parts of the National Electrical Safety Code which deal with overhead lines. It will be remembered that the Code has been submitted to the American Engineering Standards Committee for approval. Invitations have been issued to all interested bodies to attend the conference, which will be held March 2 in New York.

The following has been planned for the agenda of the conference:

1 Shall there be a set of national specifications for crossings between overhead electric wire lines and railways, and between different wire lines?
2 If so, what should be its relation on Part 2 of the National Electrical Safety Code, "Rules for the installation and maintenance of overhead and underground electrical supply and signal lines."
3 Can disposition be made of the differences of opinion on Part 2 of the National Electrical Safety Code by
a Approving the present edition,
b revising the present edition through a sectional committee of the American Engineering Standards Committee?
4 What procedure shall be recommended for carrying out the conclusions reached by the conference?

The American Electric Railway Association has summarized its reason for calling the conference as follows:

For many years various associations and interests, either individually or jointly, have developed and in many instances adopted, specifications intended to govern the construction of electric light, power, trolley, signal and communication lines across steam and electric railways.

Recently the National Bureau of Standards has promulgated the National Electrical Safety Code, Part 2 of which applies to the general construction of overhead lines, including requirements at railroad crossings. The differences between the several specifications and codes has led to confusion.

Realizing the desirability of having a standard that would be generally acceptable, the American Electric Railway Association has requested the American Engineering Standards Committee, by conference of the bodies interested, to determine the desirability of developing an American Standard Specification which will include the requirements at railroad crossings.

Insulated Wire and Cable

IN the past many engineering societies and commercial organizations have issued standard specifications for insulated wires and cables which have come into very general use. Indeed, at the present time there are something like fifteen such specifications in wide use in the United States.

All these specifications, however, are made to apply to specific industrial uses and little has been done to coördinate them. It has therefore become a matter of concern to both manufacturers

and users of wire to bring about some coördination, with the idea of establishing a definite set of American Standards.

The first step toward this was taken last winter when the following ten engineering societies and other public organizations agreed to act as Sponsors, under the auspices of the American Engineering Standards Committee, for a comprehensive standardization of electric wires and cables for other than telephone and telegraph use:

American Electric Railway Association
American Institute of Electrical Engineers
American Railway Engineering Association
American Society for Testing Materials
Associated Manufacturers of Electrical Supplies
Association of Edison Illuminating Companies
Association of Railway Electrical Engineers
National Board of Fire Underwriters
National Electric Light Association
National Fire Protection Association.

These organizations enlisted the coöperation of several others, and created a comprehensive group of committees to handle the work. The other coöperating organizations are:

Associate Bell Telephone Companies
Electric Power Club
Society of Automotive Engineers
U. S. Department of Commerce
U. S. Department of Navy
U. S. Department of War.

The first meeting of the Sectional Committee was held at the headquarters of The American Society of Mechanical Engineers on Friday, December 6, 1921. At this meeting, a formal plan of organization, and procedure was adopted, officers elected, and the work definitely launched.

There are twelve technical committees to which specific phases of the work have been assigned. Like the Sectional Committee itself, they are organized under the representational plan; that is, they are made up of representatives designated by the various organizations concerned in the particular subject with which each committee deals. These committees with their chairmen are as follows:

Definitions	W. A. Del Mar
Copper Conductors	J. A. Capp
Stranding	H. A. Morss
Rubber Insulation	F. M. Farmer
Impregnated Paper Insulation	D. W. Roper
Varnished Cloth Insulation	L. L. Elden
Magnet Wire	R. W. Longley
Fibrous Coverings	C. B. Martin
Metallic Coverings	W. I. Middleton
Standard Make-Ups	C. A. Greenidge
Export	W. S. Clark
Weatherproof, Heat-Resisting and Similar Materials.	(to be appointed later)

The officers of the Sectional Committee and other members of the Executive Committee are:

Chairman, W. A. DEL MAR, Chief Engineer, Habirshaw Electric Cable Co.

Vice-Chairman, E. B. MEYER, Asst. Chief Engineer, Public Service Electric Co., of New Jersey

Secretary, F. J. WHITE, Electrical Engineer, Okonite Company, 501 Fifth Avenue, New York

F. M. FARMER, Chief Engineer, Electrical Testing Laboratories

DEAN HARVEY, Engineer in Charge of Material Section, Westinghouse Elec. & Mfg. Co.

E. B. KATTE, Chief Engineer, Electric Traction, New York Central Railroad Co.

DANA PIERCE, National Board of Fire Underwriters.

The task before this Sectional Committee is one of the largest yet undertaken under the auspices of the American Engineering Standards Committee. The total number of engineers participating in the work is over one hundred and thirty, and the list includes most of the men who have achieved distinction in the field of wire and cable engineering.

Five Standards Approved as American Standards

A.S.T.M. Specifications. The American Engineering Standards Committee has approved as Tentative American Standard the specifications of the American Society for Testing Materials for—

Cold-Drawn Bessemer Steel Automatic Screw Stock (A32-14)
Cold-Drawn Open-Hearth Steel Automatic Screw Stock (A54-15)
Methods of Chemical Analysis of Manganese Bronze (B27-19)
Methods of Chemical Analysis of Gun Metal (B28-19)

These specifications may be found in the 1921 volume of A.S.T.M. Standards. Copies may also be obtained from the American Engineering Standards Committee, 29 West 39th St., New York City. Price 25 cents each.

Factory Lighting Code. The Code of Lighting for factory mills and other work places, based upon earlier codes issued by the Illuminating Engineering Society and recently revised by a sectional committee under the sponsorship of this society, has been officially approved as American Standard by the American Engineering Standards Committee.

The code is very brief, consisting of a few rules covering the minimum requirements, from the point of view of safety, for the illumination of traverse spaces during the time of use, methods for the avoidance of glare, and for exit and emergency lighting. Supplementary to the code are numerous suggestions relative to illumination values considered desirable for different classes of work and an outline of the advantages of good lighting.

State lighting laws based upon the I.E.S. code have already been put into effect in Pennsylvania, New Jersey, New York, Wisconsin, Oregon, California and Ohio. The adoption of the code is now under consideration in several other states. Copies of this code may be secured from the American Engineering Standards Committee, 29 West 39th Street, New York City. Price 25 cents each.

All the standards which have so far been approved by the A.E.S.C. are now available bound in a loose-leaf expanding binder appropriately stamped. We are told that recently the Chief of Ordnance of the War Department ordered four of these complete sets for the convenient use of his Department.

American Railway Association and Steel Manufacturers Join the A.E.S.C.

Beginning with 1922, the American Railway Association (Engineering Division) and the Association of American Steel Manufactures became member bodies of the American Engineering Standards Committee.

The Association of American Steel Manufacturers is an organization of forty iron and steel manufacturing companies. Its activities are limited to the standardization of rolling-mill practices, and to the standardization and inspection of iron and steel products. The association was organized in 1895. Its official representative on the American Engineering Standards Committee has not yet been designated.

The American Railway Association, which speaks for practically all the steam railways of the country, has four great technical branches, each having its own secretary, the Engineering and the Mechanical Divisions, and the Signal and the Telephone and Telegraph Sections. The Engineering Division, which is intimately connected with the American Railway Engineering Association, the two organizations having the same officers, covers broadly the civil-engineering activities of the railways. The standardization work in which the two associations are engaged, and which they have accomplished, is very extensive, both in scope and in amount. Mr. E. A. Frink, of the Seaboard Air Line Railway, who is chairman of the standardization committees of the two associations, is the representative of the American Railway Association (Engineering Division) upon the American Engineering Standards Committee.

These two new member bodies bring the total number of national organization represented upon the American Engineering Standards Committee up to twenty-eight, and of representatives to fifty-two.

NEWS OF OTHER SOCIETIES

American Society of Heating and Ventilating Engineers

Many important scientific as well as practical contributions to our knowledge of heating and ventilation were presented at the Twenty-eighth Annual Meeting of the American Society of Heating and Ventilating Engineers held at the Pennsylvania Hotel, New York, January 24 to 26, 1922. The attendance at this meeting was over four hundred. There were five professional sessions, the usual business meeting and a conference of chapter representatives with the National Committee on Chapters. Important committees reporting were those on Code of Ethics, on Legislation and on Revision of the Constitution.

The technical papers were published in the January issue of the Journal of the Heating and Ventilating Society. They included: Improvements in the Process for Cleaning and Drying Air Mechanically by William J. Baldwin; Standardized Method of Measuring Fan Delivery by E. N. Fales; Current Research in Heating and Ventilating by F. Paul Anderson; A Study in Heat Transmission with Special Reference to Building Materials by F. C. Houghton; Temperature, Humidity and Air Motion Effects in Ventilation, by O. W. Armspach and Margaret Ingels; The Control of Blower Motors by Henry G. Issertell; The Under-Feed Stoker by Frank A. DeBoos; and Heat Transfer for Conduction and Convection by W. K. Lewis, W. H. McAdams and T. F. Frost.

The officers elected for the new year were J. R. McCool, President, H. P. Gant, First Vice-President, Samuel E. Dibble, Second Vice-President, Homer Addams, Treasurer, and C. W. Obert, Secretary.

The usual entertainment features included the annual dinner-dance at the Hotel Pennsylvania, a reception-dance and functions for the ladies.

American Society of Civil Engineers

The sixty-ninth annual meeting of the American Society of Civil Engineers, held in the Engineering Societies Building, New York, January 18–20, 1922, was devoted to the subject of Transportation, one technical session being on Water Transportation, one on Railroad Transportation, and three on Highway Transportation. A large proportion of the speakers, many of whom were experts in financial and economic subjects, dealt with the economic side. At the evening session of January 19, Mr. Frank A. Vanderlip, former President of the National City Bank, delivered an address on World Activities and their Effect upon the Engineer. These features emphasized the financial aspect of the meeting, which is quite important at this time to civil engineers, since millions of dollars of contracts for civil-engineering work are being held in abeyance pending the world-wide adjustment of the financial situation.

A feature of interest at the meeting was the conferring of Honorary Memberships on five distinguished engineers, M. Charles Prosper Eugene Schneider, of Paris; Dr. Luigi Luiggi, of Rome; and Messrs. Samuel Rea, Ambrose Swasey and Howard A. Carson. M. Schneider was the recipient of the John Fritz Medal presented to him in Paris last year by the Delegation of American Engineers to Europe, and both he and Mr. Swasey are Honorary Members of The American Society of Mechanical Engineers.

Mr. John R. Freeman, Past President, Am.Soc.M.E., was elected President of the Society for the coming year.

Excursions of the meeting included visits to the Stock Exchange, the foundations of the new Federal Reserve Building, the Plant of the McGraw-Hill Publishing Company, and the Hell Gate Power Station of the United Electric Light & Power Co.

Among the speakers at the technical sessions were: Dr. Emory R. Johnson, Dean, Wharton School of Finance and Economy, University of Pennsylvania; R. H M. Robinson, President, United American Lines; Winthrop L. Marvin, Vice-President and General Manager, American Steamship Owners' Association; Samuel O. Dunn, Editor, *Railway Age;* Howard Elliott, Chairman, Northern Pacific Railway Company; William N. Doak, Vice-President, Brotherhood of Railroad Trainmen; Col. F. A. Molitor, Chairman, Board of Economics and Engineering, National Association of Owners of Railroad Securities, together with a number of Commissioners of State Highway Departments of the Eastern States and officials of various financial institutions, as well as several representatives of motor vehicle associations.

Society of Automotive Engineers

The nineteenth annual meeting of the Society of Automotive Engineers was held in New York City, January 10–13, during Automobile Show week. The outstanding feature was emphasis on research in current engineering and this was evident not only in the session devoted to that field, but in the discussions on many of the other subjects.

At the meeting of the Committee on Standards which was the first event following registration, there was a tendency toward revising old standards rather than adopting new ones. An evening session on airplane engines was devoted to the consideration of a paper on Air-Cooled Engines by Charles L. Lawrence, in which he laid particular stress on the relation of cylinder construction to satisfactory cooling.

The Annual Business Meeting on Wednesday morning opened by President David Beecroft with an account of the accomplishments of the Society during this period of Service. The balance of the session was devoted to a review of the general activities of the Society.

Among other items of interest, vice-president H. M. Crane read a report in which he pointed out the commercial achievements in aviation during 1921 and regretted the general handicap of inadequate terminal facilities which must be removed before commercial aviation can be a reality on a large scale. Vice-President Harry L. Horning gave a paper on the desirability of international affiliation of engineers in view of the general economic problems which the world is facing.

The retiring President, in his valedictory, emphasized the opportunities and responsibilities of the engineering profession in the present day. He stressed the need for professional solidarity in meeting the technical phases of the economic problems of reconstruction. The meeting was adjourned after a few remarks by the incoming President, B. B. Bachman of Philadelphia.

In the afternoon three simultaneous sessions were held, covering Body Engineering, Motor Truck Transportation and Lubrication. In the latter Winslow H. Herschel, Associate Physicist of the Bureau of Standards, presented a paper on Viscosity and Friction, one on Fluid Friction and Transmission Efficiency was read by Neal MacCord, and Robert Wilson and W. P. Barnard, 4th, gave The Mechanism of Lubrication.

Technically, at least, the high point of the meeting was reached on Thursday when at a research session the whole morning was given up to Harry Ricardo, the distinguished British engineer whose research work on the factors affecting combustion has attracted so much attention. His paper dealt with the effect of latent heat of vaporization, mean volatility, temperature, pressure, dilution, mixture strength, stratification and other factors upon combustion, and especially the detonation of various fuels for gas engines.

Simultaneous sessions were again held in the afternoon. At one on Fuel and Engines, O. C. Berry and C. S. Kegerreis presented Manifold Vaporization and Exhaust Gas Temperatures; Methods of Measuring Detonations in Engines by Thomas Midgley, Jr., and T. A. Boyd was read; and a paper on Spectroscopic Investigation of Internal Combustion by Thomas Midgley, Jr., and W. K. Gilkey. The other sessions covered Materials and included a paper by C. N. Dawe, on Chrome-Molybdenum-Steel Applications from the Consumer's Viewpoint. G. R. Norton presented Continuous Die Rolling; J. H. Nelson read his paper on Drop-Forging Practice and Enrique Touceda gave Pertinent Facts Concerning Malleable-Iron Castings.

At a Passenger Car Session Friday morning papers by J. Edward Shipper on Passenger Car Brakes; S. von Ammon on Developing a Method for Testing Brake-Lining; and Augustus Trowbridge on Photographic Recording of Engine Data were read.

The meeting was considered the most successful of its kind ever held by the Society and more than seven hundred were in attendance at the technical sessions. The social events included a dinner and carnival at the Hotel Astor.

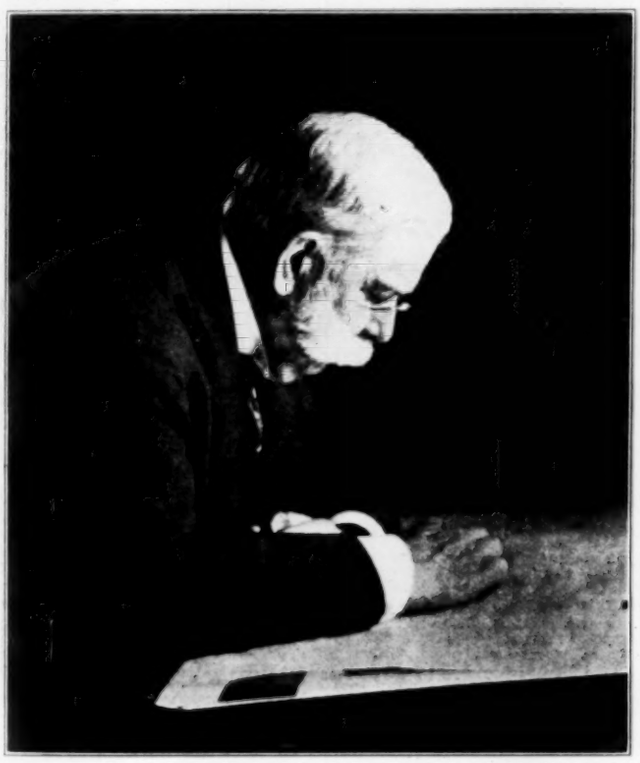
The Life of Westinghouse

By HENRY G. PROUT, C.E., A.M., LL.D.

A REVIEW BY HARRISON W. CRAVER, DIRECTOR ENGINEERING SOCIETIES' LIBRARY

SOME years ago the American Society of Mechanical Engineers published the autobiography of John Fritz. It is now responsible for recording in permanent fashion the record of another great engineer, by the publication of this handsome volume.

George Westinghouse was a man of great endowments. Strong of body, distinguished in appearance, he possessed mental powers far superior to those of most men. Formal education he never had; before he was seventeen he enlisted during the Civil War and after being mustered out, two years later, he preferred work



A FAMILIAR PICTURE OF GEORGE WESTINGHOUSE AT WORK

in his father's machine shop to a college course. From the close of his military career in 1865, until his death in 1914, he was never idle, but was absorbed in a life of inventing and manufacturing.

Such a busy life it was. Merely as an inventor, his record of a patentable invention every six weeks for forty-eight years is one that few inventors have equaled. But invention was for Westinghouse only a preliminary to manufacturing. His patents were for things to be made in his shops or used in his industries, and upon them he based a series of companies. His biographer lists 103 which he organized or assisted during their formative years. They covered America and Europe, and most of them, in one form or another still exist.

The two great achievements by Westinghouse were his solution of the problem of power braking, and his early grasp of the advantages of the alternating current for power distribution. The story of the air brake, from its inception to the perfected mechanism, is well and graphically recounted in this book. It was the first activity that brought Westinghouse into prominence and gave him fame, its supremacy has never been seriously challenged and it remains a monument to its inventor which seems to possess every quality of permanence.

No less interesting is the account of the founding, and development of Westinghouse's electrical interests. The possibilities of the alternating current were seen at an early date, and Westinghouse spent money freely and boldly to uphold his opinion. The story occupies a large portion of the book, and shows how Westinghouse, early interested in electric lighting, turned his attention from direct to alternating current machinery and proceeded confidently and doggedly to prove that his judgment was sound. Step by step the motor, the rotary converter and the distributing system were brought to commercial success, and applied to power production and railroads.

These two main lines of activity by no means exhaust the record. Westinghouse was a pioneer in the development of railway signaling and interlocking, in the natural gas industry and in perfecting the steam turbine. Many minor industries grew up under his care. Wherever he went, he observed, thought and contributed.

Colonel Prout has done a difficult piece of work with great skill. Westinghouse wrote no letters, kept no notebooks and seldom delivered addresses. He left no records to assist his biographer, who has been forced to rely upon the material obtainable from his associates and his personal acquaintance. In spite of the handicap, the record is full and coherent; the man lives, and his achievements are shown in their proper proportions. The picture given places Westinghouse in his proper place in his generation, giving the book value, not only as a biography, but as a contribution to that history of American engineering which is so greatly needed.

The reader will derive additional pleasure from the style in which the book is written. Every line shows the author's intimate acquaintance with the matters of which he speaks, and his ability to express himself appropriately. Any one interested in the lives of our engineers and the history of technical progress in our country, will lay down this book with the hope that its author and the Society will undertake further work of this kind without delay.

[The Life of George Westinghouse was first published in a subscription edition offered to the membership of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers. A popular edition has been published by Charles Scribner's Sons and may be procured through your book seller.—EDITOR]

Book Notes

AIRPLANE ENGINE. By Lionel S. Marks. First edition, McGraw-Hill Book Co., Inc., New York, 1922. Cloth, 6×9 in., 454 pp., diagrams, tables, $6.

This volume attempts to formulate existing knowledge of the functioning of the airplane engine and its auxiliaries, and to present and discuss the essential constructive details of those engines whose excellence has resulted in their survival. Most of the material is new, being based on the researches and developments that originated during the war. Professor Marks has summarized and arranged the detailed data on the engine designs used in various countries, so that it is in convenient form for the designer.

ATOMIC THEORIES. By F. H. Loring. E. P. Dutton and Co., New York, 1921. Cloth, 6×9 in., 218 pp., illus., $5.

The leading facts and theories relating to the atom, particularly those which, owing to their newness, have not yet been treated at any length in textbooks, are brought together in one volume for the convenience of students and investigators. The book covers a wide range of subjects. These include the quantum theory, Sir. J. J. Thomson's recent views of mass, matter and radiation, the Bohr theory, the octet theory, isotopes, the Brownian movement, ionization, potentials, solar phenomena and other subjects. References are given throughout, which enable the reader to follow any subject of special interest.

CONSTRUCTION, COST KEEPING AND MANAGEMENT. By Halbert Powers Gillette and Richard T. Dana. First edition. McGraw-Hill Book Co., Inc., New York, 1922. Cloth, 5×8 in., 572 pp., forms, $5.

This book has been prepared in response to requests for a second edition of Cost Keeping and Management Engineering. It contains nearly all the original material, supplemented by that developed in the last twelve years. It is intended to assist in reducing construction costs to the minimum, by explaining the rules of management and setting forth suitable methods of cost keeping, adapted to engineering construction.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada.)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photostatic copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents per page, plus postage. A separate print is required for each page of the larger periodicals, but wherever possible two small or medium-sized pages will be photographed together on the same print. When ordering photostats identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCIDENTS

Industrial. The Prodigious Cost of Industrial Accidents, Sanford DeHart. Am. Mach., vol. 56, no. 1, Jan. 5, 1922, pp. 11–13, 3 figs. Statistics on cost of accidents. Instances of reductions in absenteeism and monetary losses. Examples of simple but efficacious safety methods and appliances.

ACCOUNTING

Municipal Utilities. Standard Accounting for Municipally Owned Public Utilities. Jl. Electricity & Western Industry, vol. 48, no. 1, Jan. 1, 1921, pp. 15–16. States that merits or demerits of municipal ownership cannot be determined until there is an adequate basis of comparison of cost of operation. No such basis exists today. Discusses possibility of concealment, challenging of statements, etc.

Power Plants. Power-Plant Accounts—XVI, Wilfred A. Miller. Power, vol. 54, no. 26, Dec. 27, 1921, pp. 1013–1015, 2 figs. General scheme of accounts. (Concluded.)

AIR

Liquefaction. Recent Developments in Low-Temperature Technique (Neuere Entwicklung der Tieftemperaturtechnik), F. Pollitzer. Zeit. für die gesamte Kälte-Industrie, vol. 28, no. 9, Sept. 1921, pp. 125–133, 12 figs. Deals with development of air liquefaction and its applications. Discusses the Linde process for production of very low temperatures, and gives examples of hydrogen-recovery and oxygen plants by the Linde Ice Machine Co., Hollriegelskreuth, Germany.

AIR COMPRESSORS

Displacement, Code for. Code for Displacement Compressors and Blowers. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 45–48 and 70. Preliminary draft of fifth in series of 19 codes in course of preparation by A.S.M.E. Committee on power tests codes.

Electrically Driven. Modern Aspects in the Construction of Compressed-Air Power-Transmission Plants (Neuere Gesichtspunkte in der Ausführung von Pressluft-Kraftübertragungen). Elektrotechnische Rundschau, vol. 38, no. 11, June 7, 1921, pp. 63–65, 3 figs. Describes electric compressor constructed by German Gen. Elec. Co. (AEG) for 6000 cu.m. output per hr. and 7 atmos. excess pressure, with driving motor of 1485 r.p.m. and 1000 hp.

Machining Components. Machining Air Compressor Components. Machinery (Lond.), vol. 19, no. 480, Dec. 8, 1921, pp. 277–284, 17 figs. Review of methods employed by Reavell & Co., Ltd., Ranelagh Works, Ipswich.

Marine Diesel Engines. Design of Air Compressors for Marine Engines, David Bruce. Motorship, vol. 7, no. 1, Jan. 1922, pp. 22–24, 11 figs. Discusses compressing and cooling, single-stage and multiple-stage, compressor capacity, spring loads on compressor valves, etc.

AIRCRAFT

British. Modern British Aircraft. Flight, vol. 13, no. 45, Nov. 10, 1921, pp. 726–740, 36 figs. Deals with all the British firms at present engaged in airplane and seaplane construction.

AIRCRAFT CONSTRUCTION MATERIALS

Fabric Coverings. The Aging of Aircraft Fabric Coverings (Das Altern des Flugzeugbespannungsstoffes), Fr. Wendt. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 12, no. 22, Nov. 30, 1921, p. 325. Based on results of tensile tests with old cellonized covering fabric from upper and lower part of aerofoil and body of an airplane, the loss of strength due to meteorological influences are critically discussed.

AIRPLANE ENGINES

American Pursuit. Development of an American Pursuit Engine. Aviation, vol. 11, no. 26, Dec. 26, 1921, pp. 735–738, 2 figs. Describes developments from the Hispano to the Wright super-fighter developing 400 hp. at 2000 r.p.m. and weighing 610 lb.

British. Modern British Engines. Flight, vol. 13, no. 46, Nov. 17, 1921, pp. 750–757, 21 figs. Describes all the British aero engines being manufactured at present.

Curtiss. The Curtiss Model CD-12 400 hp. Aeronautical Engine. Aerial Age Weekly, vol. 14, no. 12, Nov. 28, 1921, pp. 273–276, 4 figs. Designed primarily for a pursuit engine to give super-performance in high-speed airplanes and now considered past the experimental stage. Detailed description and specifications.

Requirements. The Aeroplane Engine, P. E. Biggar. Eng. Inst. Can. Jl., vol. 5, no. 1, Jan. 1922, pp. 15–21, 8 figs. Requirements of aircraft propulsion and their effect on engine design.

AIRPLANES

Aerofoils. Aerodynamic Characteristics of Aerofoils—II. Nat. Advisory Committee for Aeronautics, report no. 124, 1921, pp. 89–140, 165 figs. Collection of data on aerofoils made from reports of number of leading aerodynamic laboratories of United States and Europe, and presented in a uniform series of charts and tables suitable for use of designing engineers and purpose of general reference. Continuation of Report no. 93.

Developments in Aircraft Design by the Use of Slotted Wings, F. Handley Page. Flight, vol. 13, nos. 51 and 52, Dec. 22 and 29, 1921, pp. 844–846 and 860–861, 17 figs. Deals with applications of slotted aerofoils. Results of tests.

Caproni Triplane. The 2000-Hp. Caproni Triplane (Fünfmotoren-2000-PS-Caproni-Dreidecker), E. Meyer. Zeit. für Flugtechnik u. Motorluft-schiffahrt, vol. 12, no. 22, Nov. 30, 1921, pp. 331–332, 4 figs. Machine, which is development of Caproni 3-engine commercial airplane, has five Isotta-Fraschini 400-hp. engines, speed of 140 to 150 km. per hr., and fuel consumption of 200 kg. per hr.; carrying capacity, 30 passengers and 2 pilots. Comparison with German airplanes with 4, 5 and 6 engines.

Commercial Operation. Commercial Operation of Airplanes, L. B. Lent. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 33–37. Analysis of record of Air Mail Service of U. S. Post Office Dept. for year ending Sept. 30, 1921. Author points out possible improvements, most important being use of efficient commercial planes equipped with thoroughly reliable power plant. Total operating cost, it is claimed, should not exceed 70 cents per plane-mile for single-engine planes of not over 400 hp.

Landing. The Maneuvers of Getting Off and Landing, R. M. Hill. Aerial Age Weekly, vol. 14, nos. 10, 12, 13 and 15, Nov. 14, 28, Dec. 5 and 19, 1921, pp. 228–230, 277–278, 300–302 and 348–350. Discusses in detail factors which influence getting off and landing. Lecture delivered before British Aeronautical Soc. See also discussion of above paper in Aeronautical Jl., vol. 25, no. 132, Dec. 1921, pp. 665–671.

Langley. The Langley Machine and the Hammondsport Trials. Aeronautical Jl., vol. 25, no. 132, Dec. 1921, pp. 620–647 (includes discussion), 20 figs. Discusses original Langley flying machine of 1903, and shows that the wings collapsed through faults in design and not from any failure in launching mechanism.

Mars I. Mars I's Wonderful Performance at Martlesham—212 M.P.H. Flight, vol. 13, no. 51, Dec. 22, 1921, p. 838, 1 fig. Built by Gloucestershire Aircraft Co. Results of tests.

Netherlands. New Dutch Airplanes (Neue holländische Flugzeuge), Werner v. Langsdorff. Motorwagen, vol. 24, no. 31, Nov. 10, 1921, pp. 688–692, 4 figs. Details of various models with special reference to the Fokker F III model brought out in 1921, with following specifications: Span, 16 m.; length, 10.3 m.; height, 3.2 m.; supporting surface, 42 sq. m.; engine, 185-hp. B.M.W. or 230-hp. Siddeley Puma; weight empty, 1200 kg.; loaded, 1900 kg.; carrying capacity, 5 passengers.

New Types. Work of McCook Field in 1921, T. H. Bane. Aviation, vol. 12, no. 2, Jan. 9, 1922, pp. 41–42. Describes new types of airplanes, engines and equipment developed and tested.

Pressure Distribution over Tail Surfaces. The Pressure Distribution over the Horizontal Tail Surfaces of an Airplane—I. Nat. Advisory Committee for Aeronautics, report no. 118, 1921, 86 pp., 264 figs. Account of investigation to determine pressure distribution over two horizontal tail surfaces in uniform free flight.

The Pressure Distribution over the Horizontal Tail Surfaces of an Airplane—II. Nat. Advisory Committee for Aeronautics, report no. 119, 1921, 40 pp., 85 figs. Shows that results obtained upon model tail surfaces can be used to accurately predict loads upon full-sized tail and also to find distribution of load when large elevator angles are used.

Tropical Countries. Aeroplanes in Tropical Countries, Brooke-Popham. Aeronautical Jl., vol. 25, no. 131, Nov. 1921, pp. 563–577 and (discussion) 577–580, 1 fig. Discusses particular troubles that are experienced with airplanes and engines in tropical climates, especially in Egypt and Mesopotamia, viz.: timber shrinkage, propellers, tires, shock absorber petrol supply, and hangars.

Wind-Tunnel Tests. Using Results of Tests in the Wind Tunnel for Calculating Full-Size Airplanes (Utilisation des résultats des essais faits sur petits modèles au tunnel aérodynamique pour le calcul des avions en vraie grandeur), E. Dorand. L'Aerophile, vol. 29, no. 19–20, Oct. 1–15, 1921, pp. 290–292. States that the laws of similitude do not apply exactly as between small and large models and proposes corrections necessary.

Zeppelins. Giant Airplanes of the Staaken Zeppelin Works (Grossflugzeuge der Zeppelinwerke Staaken), E. Meyer. Schweizerische Bauzeitung, vol. 78, nos. 24 and 26, Dec. 10 and 24, 1921, pp. 283–286, and 307–309, 13 figs. Dec. 10: Characteristics of Staaken R VI: Span, 42.2 m.; length, 22.2 m.; height, 6.5 m.; engines, four 260-hp. Mercedes, and one 12-hp. Mercedes for drive of a compressor installation; weight empty, 9000 kg.; total weight, 11,600 kg.; max. speed, 160 km. per hr.; climb to 3000 m., 66 min. Dec. 24: The 1000-hp. all-metal com-

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

mercial monoplane, type 1920, with 31-m. span and 3500-kg. carrying capacity; weight empty, 5000 kg.; speed, 211 km. per hr.; cabin capacity, 12 passengers.

AIRSHIPS

Colonial Service. Organisation of a Colonial Airship Service, V. C. Richmond. Aeronautical Jl., vol. 25, no. 131, Nov. 1921, pp. 588–615, 3 figs. Reviews activities in America, France and Germany; comparative value of airships and airplanes for an imperial air service; discusses general, technical, flying, and financial organization, etc.

Mooring Masts. A Portable Airship Mooring Mast. Aviation, vol. 11, no. 26, Dec. 26, 1921, p. 732, 1 fig. Describes U. S. Army Air Service mast consisting of four sections of 18 ft. each, capable of mooring ships up to 1,200,000 cu. ft. capacity.

Vacuum as Lifting Power. The Variable Vacuum Dirigible, System Vaugean-Gargiulo (Projet de dirigeable, système Vaugean-Gargiulo, à raréfaction variable), E. Garuffa. Le Génie Civil, vol. 79, no. 25, Dec. 17, 1921, pp. 536–541, 13 figs. Describes model exhibited at International Exposition and discusses principle of application of partial vacuum as an ascensive force. A crude-oil two-stroke engine used for driving.

Vacuum Dirigibles (I dirigibili a rarefazione—Il sistema Vaugean a rarefazione variabile), E. Garuffa. L'Industria, vol. 35, no. 19, Oct. 15, 1921, pp. 421–425, 10 figs. Describes the Vaugean system of airships depending on a partial vacuum for lifting power, which is variable and adjustable.

Zeppelin. The Zeppelin Commercial Airship "Nordstern" (Das Verkehrsluftschiff "Nordstern" des Luftschiffbau Zeppelin). Luftfahrt, vol. 25, no. 8, Aug. 1921, pp. 136–139, 6 figs. Specifications of airship built in 1919 and delivered to France in June 1921: Max. length, 130.8 m.; max. diam. of supporting structure, 18.71 m.; max. cross-section, 268.7 sq. m.; max. height, 21.62 m.; gas capacity, 22,550 cu. m.; covering is of cotton material entirely cellonized; engine plant includes one 2-engine and two single-engine nacelles; carrying capacity, 30 passengers, crew, 16 to 18.

ALLOYS

Fusible. Fusible Alloys (Les Alliages fusible). Sigma. La Métallurgie, vol. 53, no. 46, Nov. 17, 1921, pp. 2145–2147. Gives list of compositions for antifriction metals, solders, and other alloys.

[See also ALUMINUM ALLOYS; IRON ALLOYS; LEAD ALLOYS.]

ALUMINUM ALLOYS

Aluminum-Iron, etc. Aluminum Alloys (Note supplémentaire sur les alliages d'aluminium), Leon Guillet. Revue de Metallurgie, vol. 18, no. 10, Oct. 1921, pp. 681–684, 4 figs. Deals with aluminum-iron, aluminium-chromium, aluminium-manganese, and aluminium-cerium.

Aluminum-Zinc. The Thermal Expansion of Aluminum-Zinc Alloys (Ueber die Wärmeausdehnung der Aluminum-Zink-Legierungen), Alfred Schulze. Physikalische Zeit., vol. 22, no. 14, July 15, 1921, pp. 403–406, 1 fig. Results of experimental determinations which were made according to the tube method.

Mechanical Properties. Aluminium and its Alloys—IV, F. A. Livermore. Metal Industry (Lond.), vol. 19, no. 22, Nov. 25, 1921, pp. 420–421 and 422, 1 fig. Alloys of aluminum and copper, and aluminum and zinc, and their mechanical properties and application.

Melting. Aluminium and Its Alloys—V, Frank A. Livermore. Metal Industry (Lond.), vol. 19, no. 25, Dec. 16, 1921, pp. 496–500, 7 figs. Deals with difficulties in melting and discusses the question of pyrometric control.

Ternary Systems. Ternary Aluminum Alloys (Ueber ternäre Aluminiumlegierungen), M. Waehlert. Metall u. Erz, vol. 18, no. 12, June 22, 1921, pp. 298–307, 7 figs. From the ternary systems, copper-zinc-aluminum, copper-tin-aluminum, and iron-zinc-aluminum, alloys with maximum content of 12 per cent of heavy metal in question were produced by means of ingot casting. With their help, structure, specific weight, physical properties and formation of cutting are determined.

AMMONIA

Ammonia-Soda Process. The Heat Balance in the Ammonia-Soda Process (Die Wärmebilanz im Ammoniaksodaprozess), H. Voss. Chemiker-Zeitung, vol. 45, nos. 117 and 120, Sept. 29 and Oct. 6, 1921, pp. 940–942 and 968–970, 1 fig. Notes on chemical part and working order of process, for which attempt is made to formulate a heat balance. Lime-kiln operation, carbonic-acid compressor, ammonia compressor, etc.

Liquid, Specific Volume. Specific Volume of Liquid Ammonia, C. S. Cragoe and D. R. Harper. U. S. Bur. of Standards Sci. Papers, no. 420, Oct. 15, 1921, pp. 287–315, 3 figs. Specific volume—that is, numerical reciprocal of density—of pure liquid ammonia under pressure corresponding to saturation conditions was determined throughout temperature interval −78 to +100 deg. cent., with accuracy of about 1 part in 10,000. Review of previous work is included. Tables of specific volume and density in both metric and English units are appended.

Synthesis. The Claude Synthetic Ammonia Process, Nov. 26, 1921, pp. 665–666 and (discussion) 666–668. L. H. West. Chem. Age (Lond.), vol. 5, no. 128. Discusses catalyst vessels, catalyst material, removal of ammonia from catalyst tubes, cheap hydrogen, and industrial uses of synthetic ammonia.

ANEMOMETERS

Testing. The Testing of Anemometers, James Cooper. Trans. Instn. Min. Engrs., vol. 62, Part 1, Nov. 1921, pp. 90–99, 9 figs. Discusses results of tests showing that anemometric measurements are unreliable, especially at the working-faces where exact knowledge is necessary. See also Min. Inst. of Scotland Trans., vol. 42, Part 2, 1921–1922, pp. 44–53, 9 figs.

APPRENTICES, TRAINING OF

Present Scope, U. S. The Training of Workers in manufacture, J. V. L. Morris. Am. Mach., vol. 56, no. 3, Jan. 19, 1922, pp. 85–86. Present scope of apprenticeship in United States. Number of apprentices in various industries. Importance of apprentices in metalworking field.

ASH HANDLING

Power Plants. Ash Handling in Large Generating Stations, L. R. Lee. Power, vol. 55, no. 3, Jan. 17, 1922, pp. 86–90, 6 figs. Deals with handling and disposition of furnace ash, describes several designs of ashpits and points out merits or demerits of each. Describes different methods of ash disposal and provisions that must be made in case there is a failure in operation of ash-disposal system employed.

AUTOGENOUS WELDING

Acetylene Pressure Apparatus. Acetylene Pressure Apparatus in Switzerland (Acetylendruckapparate in der Schweiz). Autogene Metallbearbeitung, vol. 14, no. 21, Nov. 1, 1921, pp. 303–306, 8 figs. Details and operating experiences with high-pressure acetylene plants constructed by Kneubühler & Co., Zürich. Plants installed by Escher-Wyss, Zürich, and other firms have given satisfactory service.

Pipe. Autogenous Pipe Welding, H. B. Iglehart. Welding Engr., vol. 6, no. 11, Nov. 1921, pp. 21–24, 16 figs. Describes tests on welded pipe construction and shows advantages of welded joints.

AUTOMOBILE ENGINES

Chemical Control. A Chemically Controlled Automobile, George Granger Brown. Jl. Indus. & Eng. Chem., vol. 14, no. 1, Jan. 1922, pp. 6–12, 20 figs. Concludes that the combustion or explosion of a gasoline-air mixture is essentially a complex chemical reaction and as such is susceptible to chemical control. The most important consideration is the velocity of reaction, which is determined by concentration, turbulence, and temperature. Paper read before Am. Chem. Soc.

Detonation, Measuring. Methods of Measuring Detonation in Engines, Thomas Midgley, Jr. and T. A. Boyd. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 7–11, 4 figs. Discusses various methods employed to measure detonation or fuel knock, such as the listening indicator, temperature and pouncing pin, and describes latter method.

Mitchell. Entirely New Design Embodied in Mitchell Engine. Automotive Industries, vol. 45, no. 24, Dec. 15, 1921, pp. 1158–1160, 6 figs. New features include balanced crankshaft, hot-spot manifold, unusually light cast-iron pistons, pressure-feed lubrication of main bearings, improved combustion chamber form and thermostatic valve in cooling system.

Poppet-Valve. Italian Manufacturer Reverts to Poppet Valve Engine. Automotive Industries, vol. 45, no. 25, Dec. 22, 1921, pp. 1205–1208, 9 figs. Rotary valve abandoned in new 176-cu. in. four-cylinder engine which is said to develop 43 hp. at 2500 r.p.m. Large jacket space, aluminum pistons, tubular connecting rods, and four-speed gearset. Integral pressed-steel housing used for axle and propeller shaft.

Radiators. Radiator Vent Pipes. Autocar, vol. 47, no. 1365, Dec. 17, 1921, p. 1245, 3 figs. Shows how it is possible to prevent water from escaping out of radiator through vent pipe.

Rickenbacker. Original Engineering Features in New Six-Cylinder Car, J. Edward Schipper. Automotive Industries, vol. 45, no. 26, Dec. 29, 1921, pp. 1258–1261, 7 figs. Describes new Rickenbacker motor made by Rickenbacker Motor Co., Detroit. Extra flywheel at front of engine is said to minimize vibration and permit wide speed range on high gear. Cone clutch running in oil is employed.

AUTOMOBILE FUELS

Calorific Values. Royal Aircraft Establishments Reports, Nos. H. G. 410 and H. 861. Instn. Petroleum Technologists Jl., vol. 7, no. 28, Oct. 1921, pp. 339–351, 5 figs. Methods of determining calorific values of certain unsaturated hydrocarbons; and calorific values of petrols and of petrol fractions.

Sensible Fuels. Total Sensible Heats of Engine Fuels and Their Mixtures with Air, Robert E. Wilson and Daniel P. Barnard. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 65–68, 5 figs. Describes methods used by research laboratory of Mass. Inst. of Technology in determining total sensible heat content of Socony gasoline and kerosene and their mixtures with air at temperatures up to 500 deg. cent.

AUTOMOBILES

Front Axles, Machining. Front Axles and Steering Knuckles, Fred H. Colvin. Am. Mach., vol. 55, no. 25, Dec. 22, 1921, pp. 1011–1013, 10 figs. Machining operations of Peerless axle. Spring actuated drilling fixtures which are quickly handled. Holding long work for milling. Automatic lathe work on steering knuckles.

Gear Boxes. Notes on Motor Car Gear-Boxes., H. F. L. Orcutt. Engineering, vol. 112, nos. 2920, 2921 and 2922, Dec. 16, 23 and 30, 1921, pp. 830–831, 870–872 and 897–899, 8 figs. In writer's opinion, based on over 10 years' experiences, gear boxes, generally speaking, are not well designed and are badly made. Discusses defects in design, workmanship and material, and summarizes gear-tooth requirements. Paper read before Instn. Automobile Engrs. (British.)

Halley Chassis. The 35 Hp. Halley Chassis. Automobile Engr., vol. 11, no. 156, Nov. 1921, pp. 370–377, 21 figs. Has six-cylinder engine of 1,200 r.p.m. Describes clutch, gearbox, transmission and rear axle, etc.

L. Paulet. The Six-Cylinder L. Paulet (La Six Cylindres L. Paulet), H. Petit. La Vie Automobile, vol. 17, no. 743, Dec. 10, 1921, pp. 467–469, 4 figs. Describes engine, speed gear, transmissions, brakes and wheels, etc.

Painting and Varnishing. Manufacture and Application of Automobile Varnishes and Paints, L. Valentine Pulsifer. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 12–16. Specifies five basic materials necessary in automobile painting. Engineering systems of application and methods of application, including drying and surfacing. Care of finish.

Rolls-Royce Works. Rolls-Royce Methods. Eng. Production, vol. 3, nos. 63, 64 and 65, Dec. 15, 22 and 29, 1921, pp. 565–569, 589–596 and 613–618, 44 figs. Details of plant and production methods.

Service Methods. Automotive Service Methods and Equipment, Howard Campbell. Am. Mach., vol. 55, no. 26, Dec. 29, 1921, pp. 1026–1028, 10 figs., and vol. 56, no. 2, Jan. 12, 1922, pp. 59–61, 8 figs. Servicing the Rolls-Royce. Describes interesting grinding job. Kelly-Springfield truck service methods and tools. Servicing the Mack truck. Operation in a New York taxicab station.

AVIATION

Commercial. State of Commercial Aviation (Ou en est l'aviation commerciale). Roger Couturier. L'Aérophile, vol. 29, no. 21–22, Nov. 1–15, 1921, pp. 322–332, 7 figs. Discusses landing facilities, air posts, signals, French air regulations and air-lines in operation.

Development. The Trend of Aviation Development, J. G. Vincent. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 25–30. Discusses influences that are retarding development of aviation in an effort to point out the limitations that exist as differentiated from misconceived non-existent limitations and to indicate remedial measures to stimulate a vigorous growth of aviation.

B

BARRELS

Steel. The Making of Steel Pitch Barrels. Sheet Metal Worker, vol. 12, no. 25, Jan. 6, 1922, pp. 841–843, 15 figs. Describes equipment and operations for fabricating steel pitch barrels as modern shipping containers.

BEAMS

Broad-Flange. Production of Broad Flange Beams of the Grey Type at the Differdange Works [La fabrication des poutrelles a larges ailes du type Grey, aux Usines de Differdange (Luxembourg)], J. Audigé. Le Génie Civil, vol. 79, no. 21, Nov. 19, 1921, pp. 437–439, 9 figs. Discusses characteristics of Grey profiles; successive passes through different rolls for broad parallel flange beams.

Continuous. Calculation of Continuous Beams (Le calcul des portiques continus), L. Descans. Le Génie Civil, vol. 79, nos. 21 and 22, Nov. 19 and 26, 1921, pp. 439–443, and 461–464, 12 figs. Nov. 19: Discusses characteristics of continuous beams, calculation of loads, etc. Nov. 26: Analytical formulas.

Deflection. Deflections of Beams by the Conjugate Beam Method, H. M. Westergaard. Jl. Western Soc. of Engrs., vol. 26, no. 11, Nov. 1921, pp. 369–396, 28 figs. Discusses standard methods, statically determinate beams, and statically indeterminate beams.

BEARINGS, ROLLER

Railway Cars. Ball and Roller Bearings for Railway Cars (Kugel- und Rollenlager für Schienenfahrzeuge), H. Behr. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 49, Dec. 3, 1921, pp. 1260–1264, 20 figs. Explains reasons for introducing roller bearings. Suggestions for selection of suitable bearings. Roller bearings are said to have better load conditions than ball bearings. Describes new German types of bearings and discusses foreign types and their defects.

BELTING

Leather. Problems In Connection with Leather Belting, J. Edgar Rhoads. Can. Machy., vol. 26, no. 25, Dec. 22, 1921, pp. 24–25. Use of roller and ball bearings; common causes of trouble; humidity and its effect.

Reclaimed Leather. Reclaimed Leather Belting. Machy. (N. Y.), vol. 28, no. 5, Jan. 1922, pp. 363–365, 6 figs. Use of salvaged leather belts reinforced with woven cotton fabric. Processes employed by Syracuse Belting Co. in manufacture of reclaimed belting.

BENDING MACHINES

Cup-Leather Sleeve Friction. Friction of Cup-Leather Sleeves, Eugen Irlon. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 59–60, 2 figs. Presents data of tests of friction carried out in a 75-ton hydraulic bending machine water-driven by a three-piston electric pump. Translated from Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 39, Sept. 24, 1921, pp. 1016–1017.

BLIND

Employment. Employment of War-Blinded in German Industries, Hubert Hermanns. Am. Mach., vol. 55, no. 26, Dec. 29, 1921, pp. 1023–1025, 6 figs. Methods used to enable blind ex-soldiers to live inde-

pendent of charity. Machine operation in manufacturing plants.

BOILER FEEDWATER

Distilled. Distilled Water for Boiler Feed at River Rouge Plant. Power, vol. 54, no. 26, Dec. 27, 1921, pp. 998–1003, 10 figs. Elaborate two-effect high-heat-level evaporator system furnishes distilled makeup to an amount up to 25 per cent of boiler feed.

Softening. Softening and De-oxygenation of Boiler Feed Water. Chem. Age (Lond.), vol. 5, no. 130, Dec. 10, 1921, pp. 726–728. Discusses comparative merits of water-softening systems, importance of effecting oxygen removal, and chemical and physical methods for performing de-oxygenation.

BOILER OPERATION

Efficient. Better Boiler Room Operation, C. W. DeForest. Combustion, vol. 5, no. 6, Dec. 1921, pp. 246–248 and 260. Discusses investment cost; cost of fuel; and organization, personnel, supplies and maintenance costs. Paper read before Stoker Manufacturers Assn.

BOILER PLANTS

Battle Creek Sanitarium. New Boiler Plant for Battle Creek Sanitarium. Power, vol. 55, no. 2, Jan. 10, 1922, pp. 46–49, 6 figs. Installation of modern boiler house saved 10 tons of coal a day and eliminated services of 9 men from operating force. Includes full complement of instruments giving all essential operating data.

Electricity in. Electricity in Steam-Boiler Plants (Elektrizität in Dampfkesselanlagen), W. Philippi. Siemens-Zeit., vol. 1, nos. 9 and 10, Sept. and Oct. 1921, pp. 312–321 and 373–380, 21 figs. Sept.: Deals with pneumatic ash-removal installations. Oct.: Electrolytic protection of boilers against scale and corrosion. Describes method, success of which is said to have surpassed all expectations. Consists of externally generated direct current, applied through electrodes into boiler.

Management. Boiler House Management, David Brownlie. Proc. South Wales Inst. Engrs., vol. 37, no. 5, Nov. 10, 1921, pp. 405–438. Types of boilers and their relative advantages and disadvantages; mechanical stoking; economizers and feedwater heaters; superheaters; forced and induced draft; auxiliary machinery.

BOILER ROOMS

Air Supply. The Air Supply to Boiler Rooms, Richard W. Allen. Eng. & Indus. Management, (Cassier's Marine No.), Dec. 1921, pp. 35–42, 9 figs. One of most important points is that there should be equal distribution of preheated air to furnaces, so that no currents are set up and each furnace receives equal supply of air. Author deals with this problem. Results of trials taken under same conditions on one class of ship over period of four years show gains effected in each year as experience is accumulated.

BOILERS

Design. Boiler Design and Other Fuel Efficiency Factors, F. G. Lister. Ry. Rev., vol. 70, no. 1, Jan. 7, 1922, pp. 5–8, 4 figs. Discusses fuel efficiency of locomotives by attention to mechanical details. Longer combustion chambers; flexible staybolts; tight front ends; floating bushings; automatic stokers; etc.

BOMBS

Bombing and Bomb Sights. Bombing and Bombing Sights, E. J. Loring. Sci. Am., vol. 126, no. 1, Jan. 1922, pp. 49–51, 6 figs. How aiming from unstable platform of airplane is made possible.

BORING MACHINES

Standardization. Standardization and Assimilation—II, H. Varley. Eng. & Indus. Management, vol. 6, no. 23, Dec. 8, 1921, pp. 650–652, 1 fig. A scheme of standardized boring practice.

BRASS

Corrosion. The Problem of Selective Corrosion and Dezincing of Brass (La problème des corrosions sélectives et de la dézincification des laitons), F. de. Wurstemberger. Révue de Metallurgie, vol. 18, no. 11, Nov. 1921, pp. 689–712, 26 figs. Discusses in detail dezincing process and concludes that it consists of two factors, anodic dissolving of the metal and cathodic deposition of copper. Gives results of tests and indicates protective means.

BRONZE CASTINGS

Manganese. Investigation of Methods of Making Manganese Bronze Castings to Meet Air Service Specification No. 11021. Air Service Information Circular, vol. 3, no. 275, Oct. 15, 1921, 28 pp., 9 figs. For purpose of developing satisfactory method for making manganese bronze in small foundry; standardizing method of separately casting test specimens as a check on melts of small castings of this metal; and determining best physical properties obtainable in manganese bronze as determined by this standard test bar, and comparing these with results obtained on test bars cut from actual castings.

BRONZES

Manganese. Manganese Bronze, Frank A. Livermore. Metal Industry (Lond.), vol. 19, no. 23, Dec. 2, 1921, pp. 445–446. Shows that manganese bronze may be manufactured from scrap metal without resorting to use of high-grade virgin metal.

C

CAR LIGHTING

Methods. Railway Car Lighting (L'éclairage des voitures de chemins de fer), M. Bougrier. L'Électricien, vol. 52, nos. 1287 and 1288, Nov. 1, and 15, 1921, pp. 481–488 and 505–513, 11 figs. Nov. 1: Describes the various methods in use in different countries, including lighting by candle, oil, gas, acetylene, and electricity, and gives cost data. Nov. 15: Describes the Brown-Boveri individual electric equipment, its operation and upkeep.

CAR WHEELS

Foundry. A Unique Foundry for Production of Car Wheels. Can. Foundryman, vol. 12, no. 11, Nov. 1921, pp. 17–20, 6 figs. Molds are placed on semi-automatic moving platform and taken to place of pouring; shaking out and annealing with very little effort.

Tires, Sorbitic Steel. Sorbitic Steel for Tires. Engineer, vol. 132, no. 3442, Dec. 16, 1921, p. 636, 4 figs. on p. 657. Includes tables showing results of tests made with three railway and three tramway tires, one of each set being treated by the Sandberg Sorbitic steel process. Results show that process is successful in obtaining improved ultimate tensile strength and hardness of tires.

CARS

Connectors. The Development of the Robinson Connector. Ry. Age, vol. 71, no. 26, Dec. 24, 1921, pp. 1259–1263, 9 figs. Detailed description of new design incorporating a number of improvements.

CARS, COAL

Electric Tippers. Electrically Equipped Railway Truck Tippers, E. H. Rousham. Electrician, vol. 87, no. 2276, Dec. 30, 1921, pp. 822–825, 10 figs. Describes the Babcock & Wilcox tipping ram, and the tipper manufactured by Ed. Bennis & Co., Ltd.; also overhead winch type, hydraulic tipping rams, electric rotary tipplers, clamping methods, automatic clamping gear, etc.

CARS, FREIGHT

Wood Construction. The Use of Wood in Freight Car Construction, H. S. Sackett. Ry. Mech. Engr., vol. 96, no. 1, Jan. 1922, pp. 27–32, 6 figs. Advantages of composite design as against all-steel construction; relative advantages of double and single sheathed box car; composite gondola car; refrigerator car.

CARS, PASSENGER

Electric Railway. New Stock For Tynemouth Electrified Branches, North Eastern Railway. Ry. Gaz., vol. 35, no. 24, Dec. 9, 1921, pp. 877–884, 12 figs. Passenger vehicles of improved design built for this important electrified passenger service.

Sleeping. New Sleeping Cars for the Canadian Pacific. Ry. Age, vol. 71, no. 27, Dec. 31, 1921, pp. 1301–1394, 7 figs. Composite cars of 12-section and compartment types have special facilities for comfort of passengers.

CASE-HARDENING

Iron and Steel. Case Carburizing of Iron and Steel (Härtung von Eisen und Stahl), Willy Hacker. Metall-Technik, vol. 47, no. 14, Sept. 15, 1921, pp. 85–87. Review of development and processes during last few years.

CASTING

Metal Molds. Casting in Metal Moulds, S. A. E. Wells. Metal Industry (Lond.), vol. 19, no. 25, Dec. 16, 1921, pp. 501–502. Discusses the three classes, viz., (1) that in which metal flows into mold under force of its own weight, (2) die castings, and (3) part chills in ordinary sand molds. From paper read before joint meeting of Inst. of Metals and Instn. British Foundrymen.

Permanent Molds. Permanent Moulds, Edward D. Gleason. Metal Industry (Lond.), vol. 19, no. 20, Nov. 11, 1921, pp. 377–379. Description of methods of making plaster molds for finished castings to eliminate machining operations.

CELLULOID

Manufacture. Manufacture of Pyroxylin Plastics, J. R. DuPont. Chem. & Met. Eng., vol. 26, no. 2, Jan. 11, 1922, pp. 65–70, 6 figs. Properties of celluloid; methods of mixing cellulose nitrate with camphor and alcohol; stabilizing; filtering; rolling; baking; sheeting; polishing; etc.

CHROME STEEL

Ball-Bearing. The Manufacture of Chromium Ball-Bearing Steel in the Heroult Furnace, F. T. Sisco. Chem. & Met. Eng., vol. 26, no. 2, Jan. 11, pp. 71–76, 2 figs. Description of melting and processing of electric ball-bearing steel, with a view of the most serious defects in this class of material. Recommended pratice for elimination and control of these defects.

Chrome-Molybdenum. Chrome-Molybdenum-Steel Applications from the Consumer's Viewpoint, C. N. Dawe. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 47–50 and 62, 2 figs. Gives results of physical tests, comparing medium-carbon, chrome-molybdenum, chrome-vanadium, chrome-nickel and chrome steels. Discusses case-hardening grades of Steel.

COAL HANDLING

Equipment. Springdale Mine Furnishes Fuel to West Penn Power Co. Plant, Cleaning Every Car of Coal Before Weighing, D. J. Baker. Coal Age, vol. 20, no. 25, Dec. 22, 1921, pp. 993–999, 6 figs. Power plant situated next to headframe. For weighing, coal is screened to lump, nut and slack before picking; nut and slack are united and reassembled; lump is then crushed and with nut and slack goes to boilers.

Plants. Up-to-Date Coal and Ash Handling Plant at the Cordite Factory, Poole. Eng. & Indus. Management, vol. 6, no. 24, Dec. 15, 1921, pp. 701–704, 8 figs. Railway sidings on which coal arrives and on which ashes leave, run alonside of and parallel with boiler house; full trucks arrive on inner track and pass an unusually large track hopper into which coal is dumped by truck tippler.

COAL STORAGE

Concrete Bins and Pits. Economy of Concrete Bins and Pits for Coal Storage, A. C. Irwin. Elec. Rev. (Chicago), vol. 79, no. 22, Nov. 26, 1921, pp. 811–816, 16 figs. Storage requirements and methods, including submerged pits; effect of storage on properties of coal; spontaneous combustion.

COMBUSTION

Gas Mixed with Air. Perfect Combustion of Gas by Mixing With Air (Réalisation de la combustion par faite du gaz par son mélange préalable, incomplet avec de l'air), A. Grebel. Chaleur et Industrie, vol. 2, no. 20, Dec. 1921, pp. 794–802, 14 figs. Recent progress in construction and operation of gas apparatus and gas burners, application in welding, annealing, etc.

COMPRESSED AIR

Handling Material by. Handling Material by Compressed Air, F. A. McLean. Can. Machy., vol. 26, no. 25, Dec. 22, 1921, pp. 19–23, 10 figs. Time is saved and economy effected. Notes on single acting air hoists, capacities of straight lift hoists, and operating costs.

Intercooling. Value of Intercooling Compressed Air, C. K. Bennett. Nat. Engr., vol. 25, no. 12, Dec. 1921, pp. 613–616, 6 figs. Advantages of intercooling. How saving in power is effected and safety maintained.

CONVEYORS

Machinery for Elevators and. Conveying and Elevating Machinery, Gardiner Mitchell. Engineering, vol. 112, no. 2921, Dec. 23, 1921, pp. 866–870, 17 figs. Deals with the various types of conveyors and elevators, and includes tables giving standard details and particulars, and standard elevator chains.

Steel-Band. The Use of Steel Bands for Power Transmitting and Conveying Purposes, Bernard Kruger. Jl. Western Soc. of Engrs., vol. 26, no. 12, Dec. 1921, pp. 428–432. Discusses increased use of steel bands, avoiding breaks in band, composition and tensile strength of bands, and compares leather, rope, chain and steel band systems.

COPPER

Working and Annealing. Experiments in the Working and Annealing of Copper, F. Johnson. Engineering, vol. 112, no. 2922, Dec. 30, 1921, pp. 899–901, 7 figs. Results of rolling and hardness tests and specific gravity tests. Notes on annealing of rolled strips, and influence of impurities on effective annealing temperature of cold-drawn copper. (Abstract.) Paper read before Inst. Metals (British).

CORK

Artificial. Artificial Cork, Ismar Ginsberg. Sci. Am., vol. 126, no. 2, Feb. 1922, p. 91, 5 figs. Waste materials used in its manufacture and applications found for it.

CORROSION

Investigations. Corrosion Investigations, D. M. Strickland. Sci. Am., vol. 126, no. 2, Feb. 1922, p. 104, 2 figs. Some of controlling factors, and how account is best taken of them.

COST ACCOUNTING

Idleness Expense Charts. The Cost of Mismanagement, E. A. Lucey. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 25–28, 4 figs. How it can be measured through idleness. Shows examples of Gantt idleness charts.

COSTS

Construction. Calculation of Costs in Engineering Construction (Die Kostenberechnung im Ingenieurbau), Hugo Ritter. Schweizerische Bauzeitung, vol. 78, nos. 10 and 11, Sept. 3 and 10, 1921, pp. 116–119 and 131–133. Suggestions as to how the separate expense items which go to make up total cost of a work can best be determined. Deals with cost of labor and material, mechanical equipment, transportation, general expenses, etc.

Foundry. Foundry Costs and Establishment Charges, Daniel Adamson. Engineering, vol. 112, no. 2922, Dec. 30, 1921, pp. 894–895. Author endeavors to arrive at a reliable method of estimating cost of many varieties of castings in green sand, dry sand or loam, that are produced in foundry attached to a general engineering business. Notes introducing discussion before Manchester Assn. Engrs.

CRANES

Hooks for, Strength of. The Strength of a Hook or "Clivvy," Charles D. Mottram. Quarry & Surveyors' & Contractors' Jl., vol. 26, no. 297, Nov. 1921, pp. 447–449, 4 figs. Discusses safety load and factor of safety; gives curves and formulas.

Overhead Drives. Overhead Crane Drives, A. W. Knight. Machinery (Lond.), vol. 19, no. 482, Dec. 22, 1921, pp. 352–354, 4 figs. Describes some typical cranes and works out amount of movement of one side of crane in advance to the other, when the crab and its suspended load is at opposite end to drive on cross shaft.

Shifting Gear on Gantry. Use Shifting Gear on German Cranes. Iron Trade Rev., vol. 70, no. 2, Jan. 12, 1922, pp. 140–142, 5 figs. Describes gantry cranes equipped with swivel trucks and lifting jacks by means of which whole crane may be quickly and readily transferred from one runway to another. Built by Fried. Krupp Corp., Magdeburg-Buckau.

CRANKSHAFTS

Manufacture. The Manufacture of Crankshafts. Engineering, vol. 112, nos. 2919, and 2920, Dec. 9 and 16, 1921, pp. 777–778, 9 figs. partly on supp. plate, and pp. 811–813, 14 figs. Describes works and manufacturing methods of Clarke's Crank & Forge Co., Ltd., Lincoln, England.

CUTTING TOOLS

Diamond. Manufacture and Use of Diamond Cutting Tools, Ellsworth Sheldon. Am. Mach., vol. 56, no. 2, Jan. 12, 1922, pp. 53–56, 8 figs. Study of structure necessary to secure keen cutting edges. Cleaving the diamond.

D

DIE CASTING

Plant Organization. Modern Production of Die-Molded Castings (Neuzeitliche Pressgussherstellung), Harry Baclesse. Elektrotechnische Rundschau, vol. 38, no. 18, Sept. 21, 1921, pp. 105–107, 1 fig. Describes organization of modern plant for making die-molded castings and reviews metals now commercially used in die-casting practice.

DIES

Continuous Rolling. Continuous Die Rolling, G. R. Norton. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 43–46, 11 figs. Describes process of continuous die rolling; improvements made; physical characteristics of steels; cost of operation; equipment used; etc. See also Iron Age, vol. 109, no. 3, Jan. 19, 1922, pp. 207–209, 11 figs.

DIESEL ENGINES

Air Compressors. See AIR COMPRESSORS, Marine Diesel Engines.

Generator Drive. Oil-Engine-Driven Ship Generators in the Germany Navy (Der ölmotorische Antrieb von Borddynamos in der deutschen Kriegsmarine), W. Laudah. Schiffbau, vol. 22, no. 34, May 25, 1921, pp. 813–819 and vol. 23, no. 12, Dec. 21, 1921, pp. 329–339, 10 figs. Notes, including official data, on development of high-speed Diesel engines for dynamo drive. May 25: Fundamental principles of construction. Dec. 21: Results of tests with different types; engines of 300-kw. output. The opposed-piston-type engines built by Weser Corp., Bremen, for the liner, Markgraf. (To be continued.)

Investigations. Investigations of Diesel Engines (Untersuchungen an der Dieselmaschine), Kurt Neumann. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 245, 1921, 42 pp., 18 figs. Based on tests, results of which are presented in tables and diagrams, progress of combustion and interchange of heat between gas and cylinder wall are determined. Progress of combustion is determined by means of indicated diagrams and from composition of gas specimens taken from working cylinder of engine. Thermodynamical calculations are based strictly on measurements and are entirely free from arbitrary assumptions. Analysis of injection and combustion process. Calculation of loss of work due to conduction through walls of cylinders.

DRILLING MACHINES

Heavy-Duty. Economy of Heavy-duty Drilling, Fred R. Daniels. Machy. (N. Y.), vol. 28, no. 5, Jan. 1922, pp. 349–355, 16 figs. Examples of work for which heavy-duty drilling machine is adapted.

DROP FORGINGS

Heat Treatment. Heat-treatment of Drop-forgings. Machy. (N. Y.), vol. 28, no. 5, Jan. 1922, pp. 384–388, 6 figs. Furnace design and fuels suitable for treating drop forgings.

DUST

Collectors. Mechanical Methods of Allaying Dust, P. H. Warren. Australasian Inst. Min. & Metallurgy Proc., no. 42, June 30, 1921, pp. 31–47 and (discussion) 47–100, 10 figs. Describes tests carried out at Borken Hill South mine with the Clifton dust collector.

E

EDUCATION, ENGINEERING

Industrial Needs. Engineering Education. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 1–7 and 42. Group of papers in which are presented particular needs of industries and problems that confront engineering faculties: Professional Engineering Education for the Industries, Francis C. Pratt. A National Policy on Engineering Education, A. G. Christie. Engineering Education as Viewed by the Industrialist, J. E. Otterson.

EDUCATION, INDUSTRIAL

Germany. The Training Schools of the German Mechanical Industry (Die Werkschulen der deutschen mechanischen Industrie). Betrieb, vol. 3, nos. 23, 25 and 26, Aug. 27, Sept. 15 and 25, 1921, pp. 53–56, 57–64 and 65–76, and vol. 4, no. 2, Oct. 22, 1921, pp. 1–9. Notes on training schools of most important German industrial works.

ELECTRIC DRIVE

Sugar Mills. Electric Drive for Sugar Mills, Charles Griffith. Sugar, vol. 24, no. 1, Jan. 1922, pp. 33–34. This type of power development has advantage of flexibility and many economies are effected by unit drive.

Wool Cards. Group vs. Individual Drives on Wool Cards, Alonzo B. Reed. Textile World, vol. 61, no. 1, Jan. 7, 1922, pp. 63–65 and 81, 2 figs. General comparison of first cost, power consumption, maintenance, cleanliness and flexibility of operation with different systems of driving. Tests made under actual mill conditions before and after cards were equipped with individual motors.

ELECTRIC FURNACES

Arc, Operation of. The Operation of Basic Electric Furnaces, M. W. Caruthers. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 17–19. How to avoid delays in each of the eight major operations of making steel in furnaces having movable electrodes.

Basic. Basic Electric Furnace for Cast Iron. Can. Foundryman, vol. 12, no. 11, Nov. 1921, pp. 32–34. Important characteristics of refining in the basic-hearth electric furnace are: (1) it is strongly reducing, (2) it is degasifying to an appreciable extent, (3) it is cleansing of entrained slags and oxides, and (4) it is intensely desulphurizing.

Electrodes. Electric Furnace Electrode Has Undergone Marked Development, A. T. Hinckley. Elec. World, vol. 78, no. 26, Dec. 24, 1921, pp. 1263–1265. Reviews uses of carbon electrodes from 1800 to present day applications in electric furnace.

Forging. Builds Electric Forging Furnace, G. M. Little. Iron Trade Rev., vol. 69, no. 26, Dec. 29, 1921, pp. 1689–1692, 3 figs. Discusses difficulties encountered in construction of carbon resister-type furnace for heat treating and forging work. Gas or oil used to prevent resister oxidation. Insulation problem solved.

Gray-Iron. Practical Aspects of Electric Gray Iron, C. H. Vom Baur. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 51–52. Advantages over the cupola. Actual results from heats made recently. Effect of nickel and chromium. Comparative costs.

Induction. Melting Steel in an Induction Furnace, H. A. Winne. Iron Trade Rev., vol. 70, no. 2, Jan. 12, 1922, pp. 138–139, 2 figs. Describes induction furnace of 4000-lb. hearth capacity in successful operation at Pittsfield works of Gen. Elec. Co. for more than a year. It is a single-phase, single-ring (horizontal) type; lining consists of two essential parts, an outer layer of insulating and refractory brick, and inner rammed lining, or hearth proper.

Railway Shops. The Electric Furnace on Railroad Work, Larry J. Barton. Western Machy. World, vol. 12, no. 11, Nov. 1921, pp. 444–446, 4 figs. Describes installation of Southern Pacific Co. at their Sacramento shops; 6-ton Heroult furnace.

Reactance Requirements. Furnace Reactance Requirements Need Consideration, P. B. Short. Elec. World, vol. 79, no. 2, Jan. 14, 1922, pp. 81–83, 4 figs. Discusses growing tendency to use higher operating voltages and the importance which public utilities are attaching to power factor.

Steel. Electric Furnace Best for Conditions on the Pacific Coast, L. J. Barton. Jl. Electricity & Western Industry, vol. 47, no. 12, Dec. 15, 1921, pp. 463–464, 1 fig. In iron and steel manufacture efficiency of electric furnace and high quality of product offset absence of coking coal necessary for blast furnace methods.

ELECTRIC LOCOMOTIVES

Paulista Railway D. C. 3000 Volt Direct-Current Locomotives for the Paulista Railways, John A. Clarke, Jr. Elec. Jl., vol. 19, no. 1, Jan. 1922, pp. 17–23, 11 figs. Discusses electrification of Jundiahy-Campinas section of the Sao Paulo state railway, and gives data on passenger and freight locomotives and auxiliaries.

Storage-Battery. Data on Operation of Storage Battery Locomotive, Jerome C. White. Coal Industry, vol. 4, no. 12, Dec. 1921, pp. 581–583, 2 figs. Costs and operating data obtained from a storage-battery locomotive used as a main haulage machine. Paper read before Coal Min. Inst. of Am.

Explosion Proof Electric Mine Locomotives, L. C. Illsley. Coal Industry, vol. 4, no. 12, Dec. 1921, pp. 588–591, 9 figs. Description of work being carried on by Bur. of Mines in connection with investigations of storage-battery locomotives; requirements for approved equipment; rules for inspection.

Haulage Work with Storage-Battery Locomotives Without Driver (Förderbetrieb mit fuhrerlosen Akkumulator-Lokomotiven), H. Trautvetter. Fördertechnik u. Frachtverkehr, vol. 14, no. 23, Nov. 11, 1921, pp. 287–289, 4 figs. Maximum speed of locomotive is 1 m. per sec.; efficiency, 80 to 100 km. per 8 hr.; under these conditions capacity of batteries is sufficient for 8000 to 10,000 m. Enumerates advantages of driverless locomotives.

ELECTRIC PLANTS

Automatic. Automatic Plant Permits Development of Small Power Site, C. M. Gilt. Elec. World, vol. 78, no. 25, Dec. 17, 1921, pp. 1213–1214, 3 figs. Generator started simply by energizing line connecting automatic plant to main station.

Commonwealth Edison Co., Chicago. Calumet Station of the Commonwealth Edison Co., A. D. Bailey. J. Western Soc. of Engrs., vol. 26, no. 12, Dec. 1921, pp. 420–427, 9 figs. Discusses station now under construction, with ultimate capacity of 180,000 kw.; present installation consists of one 30,000-kw. Westinghouse Tandem compound unit and one 30,000-kw. General Electric unit. Boiler station to consist of seven 1,500-hp. Babcock & Wilcox boilers fired with forced-draft chain-grate stokers and augmented with superheaters and steel-tube economizers.

Hartford Electric Light Co. Station Electrical Layout for Supplying Local and Regional Service. Elec. World, vol. 78, no. 26, Dec. 24, 1921, pp. 1269–1273, 9 figs. Flexibility and simplicity of design effectively combined in South Meadow station of Hartford Elec. Light Co. Symmetrical development by sections to meet dual service.

Possible Economies. Possible Economies in Large Electric Generating Stations, Emile Rauber. Engineer, vol. 132, no. 3444, Dec. 30, 1921, pp. 699–670. States that considerable progress may still be made in economizing fuel by (1) using higher steam pressures; (2) employing higher degree of superheat; (3) heating feedwater by "bleeding" turbines; and (4) preventing all losses of heat. (Abstract.) Report of Commission appointed by French Minister of Pub. Works, printed in Journal Officiél.

ELECTRIC POWER

Industrial Load, Pennsylvania. The Industrial Load in Pennsylvania. Elec. World, vol. 78, no. 27, Dec. 31, 1921, pp. 1313–1317, 3 figs. Electrical energy consumed by all industrial plants of Pennsylvania during 1920 is estimated at 4,666,928,000 kw-hr., 50.3 per cent of which is purchased from central generating and distributing systems.

ELECTRIC WELDING, ARC

Boiler Repairs. Electric Arc Welding for Boiler Repairs. Ry. Elec. Engr., vol. 12, no. 11, Nov. 1921, pp. 415–420, 19 figs. Special committee of Master Boiler Makers' Assn. reports best methods of reconditioning boilers.

Cyc-Arc Process. The "Cyc-Arc" Process of Automatic Electric Welding, L. J. Steele and H. Martin. Electrician, vol. 87, no. 2273, Dec. 9, 1921, pp. 734–735. Discusses development; and the three essential variables, viz., (a) amount of current through the arc, (b) length of arc upon striking, and (c) length of time it had to be maintained before making the weld. Results of welding experiments and tests with the cyc-arc apparatus.

ELECTRIC WELDING, RESISTANCE

Methods and Apparatus. Electric Resistance Welding (La soudure électrique par résistance), R. Verdier. La Nature, no. 2480, Oct. 15, 1921, pp. 246–251, 7 figs. Describes the three methods and apparatus used.

Railway Shops. Experiences with Machines for Electric Resistance Welding in Railway Shops (Erfahrungen mit Maschinen zum Schweissen durch elektrischen Widerstand in Eisenbahnwerkstätten), W. Bastänier. Organ für die Fortschritte des Eisenbahnwesens, vol. 76, no. 17, Sept. 1, 1921, pp. 177–179, 5 figs. Describes machines by Moll Works Corp., Chemnitz, Germany, for butt-welding and spot welding, and experiences therewith in railway shop.

EMPLOYEES' REPRESENTATION

Advantages. Pulling Together Through Representation, John T. Broderick. Management Eng., vol. 1, no. 6, Dec. 1921, pp. 331–334 and vol. 2, no. 1, Jan. 1922, pp. 31–36. Dec. Points out that right understanding comes from joint conference of employer and employee. Jan. Manufacturer explains plan adopted in his plants. Describes how general committee is formed, how wage problem is solved, and production helped, attitude of organized workers, problem of unemployment, welfare work, etc.

EMPLOYMENT MANAGEMENT

Adaptability Tests. How to Develop Psychological Adaptability Tests (Wie entwickelt man phychologische Eignungsprufungen), Hans Rupp. Betrieb, vol. 4, no. 4, Nov. 26, 1921, pp. 96–105, 15 figs. The most important practical fundamentals for development of reliable adaptability tests are set forth.

Psychotechnical Adaptability Testing of Prospective Female Workers for Mass Production in the Electrical Industry (Psychotechnische Eignungsprüfung von anzulernenden Arbeiterinnen der elektrotechnischen Massenherstellung), M. Waldau. Betrieb, vol. 4, no. 4, Nov. 26, 1921, pp. 110–117, 27 figs. Describes methods and testing apparatus and their evaluation.

ENAMELING

Cast Iron and Steel. Enameling Cast Iron and Steel Materials, F. L. Prentiss. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 13–16, 9 figs. Methods and apparatus used. Care needed in preparing surfaces for treatment. Burning on the enamel.

ENAMELS

White, for Copper. The Production of Some White Enamels For Copper, R. R. Danielson and H. P. Reinecker. Am. Ceramic Soc. Jl., vol. 4, no. 10, Oct. 1921, pp. 827–834. Describes investigations for developing white enamels for copper watch dials, thermometer scale plates, and signs. Preparation of enamels; application and firing of enamels.

ENGINEERING

Western Home for. Proposed Western Home for Engineering and Industry, Robert Sibley. Jl. Electricity & Western Industry, vol. 47, no. 11, Dec. 1, 1921, pp. 426–427, 1 fig. Discusses plans for financing and managing a large building in San Francisco to be used as center for all classes of engineering.

ENGINEERING SOCIETIES

Engineering Association Plans. The Engineering Association and Its Plans, C. S. Kimball. Elec. Ry. Jl., vol. 59, no. 1, Jan. 7, 1922, pp. 18–20, 1 fig. Discusses work of reorganization of Am. Elec. Ry. Assn.; outlines committee problems and activities; participation in national standardization; etc.

ENGINEERS

License Law, N. Y. State. The New York State License Law, S. G. George. Cornell Civil Engr., vol. 30, no. 4, Jan. 1922, pp. 53–54. Professional engineers and land surveyors required to obtain

licenses to practice in New York State from May 5, 1923.

ENGINEHOUSES

Enterior Turntable. Rectangular Enginehouse with Interior Turntable. Eng. News-Rec., vol. 87, no. 26, Dec. 29, 1921, pp. 1064–1066, 4 figs. Two Canadian railways adopt novel plan to reduce winter trouble at terminal by putting turntable under cover

EXHAUST STEAM

Utilization. Utilization of Exhaust Steam in Industries (Abdampfausnutzung in der Industrie), J. Gramberg. Gesundheits-Ingenieur, vol. 44, no. 51, Dec. 17, 1921, pp. 633–638 and (discussion) pp. 638–641, 8 figs. Discusses conditions essential for design and efficient operation of plant for utilizing exhaust steam. Address before Heating & Ventilating Congress at Munich.

F

FACTORIES

Layout. Factory Lay-out as an Aid in Reducing Costs. Machinery (Lond.), vol. 19, no. 480, Dec. 8, 1921, pp. 293–296, 8 figs. Describes new plant of Colburn Machine Tool Co., Cleveland, Ohio, which has been laid out with a view to economy in manufacturing.

Laying Out a Factory for Production Work, Frank W. Curtis. Am. Mach., vol. 56, nos. 2 and 3, Jan. 12 and 19, 1922, pp. 56–58 and 97–99, 8 figs. How kind and amount of equipment are estimated. Arranging machines. Uses of operation sheets, equipment records, and conveyors.

Telephone. Methods in a Telephone Factory. Eng. Production, vol. 3, no. 64, Dec. 22, 1921, pp. 583–587, 14 figs. Describes works and practice of British L. M. Ericsson Mfg. Co., Ltd., at Beeston, for manufacture of telephones, telephone exchange and private branch switchboards and allied apparatus cabinet work, etc.

FACTORY MANAGEMENT

See INDUSTRIAL MANAGEMENT.

FILING SYSTEMS

Z Charts. Filing the Z Chart, Arthur R. Burnet. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 47–50, 2 figs. Describes system of filing which, it is claimed, follows principles best suited to classification and indexing of accounting records.

FLIGHT

McCook Field Altitude. Functioning of Supercharger in Altitude Flight. Aviation, vol. 12, no. 2, Jan. 9, 1922, p. 51. Excerpt of report of John A. MacReady on his record-breaking altitude flight at McCook Field, dealing with technical aspects of flight and giving summary of data obtained with respect to supercharger, engine and propeller.

Soaring. The Starting of Soaring Airplanes (Start von Segelflugzeugen), E. Offermann. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 12, no. 22, Nov. 30, 1921, pp. 327–331, 13 figs. Investigation of following problems is said to be necessary in order to diminish danger to life and material: Improvement in airplane construction that will render it possible to start and fly with as low a wind as possible; training of pilot especially for motorless or soaring flight; study of relationships between formation of land and nature of soil and air movements, and their dependence upon one another.

FLOW OF LIQUIDS

Resistance in Glass Tubes. The Resistance of Liquids Flowing in Short Tube Sections (Ueber den Widerstand strömender Flüssigkeit in kurzen Rohrstücken), L. Schiller and H. Kirsten. Physikalische Zeit., vol. 22, no. 19–20, Oct. 1–15, 1921, pp. 523–528, 7 figs. Discussion of experimental results obtained by W. Sorkau in investigation of friction of liquids in glass tubes.

FLOW OF WATER

Spiral Riveted Pipe. Flow of Water Through Spiral Riveted Steel Pipe, F. W. Crewe and R. R. Martin. Eng. & Contracting, vol. 57, no. 2, Jan. 11, 1922, pp. 41–42, 2 figs. Data and results of investigation upon flow of water through 4, 6, 8 and 10-in. galvanized spiral riveted steel pipes, dealing primarily with relation of friction loss to velocity in straight runs, both when flow was directed with and against lap. (Abstract.) Bul. Eng. Experiment Station of Purdue University.

FORGING

Instruction Sheets. Instruction Sheets for Forging (Schmiedeakkorde), F. Lohage. Werkstattstechnik, vol. 15, nos. 10 and 11, May 15 and June 1, 1921, pp. 281–294 and 317–327, 48 figs. Instruction sheets for forging various machine parts, etc., with line allowance for each operation. Illustrations of forging tools and their application.

Mild Steel. Forging Experiments with Mild Steel, Paul J. Junkers. Forging & Heat Treating, vol. 7, nos. 10 and 11, Oct. and Nov. 1921, pp. 518–523 and 553–556, 22 figs. Oct.: Results of experiments to determine resistance of steel to deformations and influence of kneading and forging temperatures upon physical properties of a 0.13 and 0.50 C steel Nov.: Improvement in structure due to forging is greater in 0.50 than in 0.13 carbon steel; finishing temperatures important.

FOUNDRIES

Brass. Casting Small Parts in Production Foundry, Gerard Frazar. Iron Age, vol. 108, no. 26, Dec. 29, 1921, pp. 1653–1656, 7 figs. Describes new foundry of Gilbert & Barker Mfg. Co., Springfield, Mass., equipped for continuous pouring which when run at capacity will give employment to about 300.

Chilled Rolls. New Foundry for Casting Chilled Rolls, George F. Tegan. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 38–42, 7 figs. Raw material charged in air furnaces direct from stock pile at Garrison foundry, Pittsburgh.

Core Mixing. Core and Sand in the Foundry, G. Pouplin. Brass World, vol. 17, no. 12, Dec. 1921, pp. 345–350. The making and mixing of cores as practiced today in the best French foundries. Notes on core drying, glutrin and avehene, and action of tar-oil on sand. (Abstract.) From Fonderie Moderne.

Engineering Costs. Obtaining Engineering Costs in Foundry and Machine Shop, Howell B. May. Iron Trade Rev., vol. 69, nos. 19, 21, 23 and 25, Nov. 10, 24, Dec. 8 and 22, 1921, pp. 1218–1221, 1356–1358, 1456–1458, 1485–1489 and 1619–1622 and 1630, and vol. 70, no. 3, Jan. 19, 1922, pp. 206–210, 30 figs. Survey of needs and advantages of adequate costs with detailed application of cost system to plant having iron and brass foundries, machine shop and sheet-metal department. Nov. 10: General outline of plan. Nov. 24: Cost plan in detail. Dec. 8: Burden and expense account. Dec. 22: Consolidation of cost and general accounting. Jan. 19: Financial statements, graphics and control.

Railway Iron and Steel. Control in a Railway Iron and Steel Foundry, G. N. Shawcross. Engineering, vol. 112, no. 2920, Dec. 16, 1921, pp. 832–836, 6 figs. Outlines examples of control of men, methods and materials in well-known locomotive works of Lancashire & Yorkshire Ry. at Horwich, England, showing what output is produced and by what methods work is turned out. Address delivered before Cambridge University Eng. Soc.

Sand-Dressing Plants. Automatic Sand-Dressing Plant (Selbsttätige Sandaufbereitungsanlagen), H. Kalpers. Zeit. für die gesamte Giessereipraxis, vol. 42, no. 37, Sept. 10, 1921, pp. 481–484, 8 figs. Describes new plant by the Gustav Zimmermann Machine Works, Düsseldorf, which is said to produce a sand of always uniform and excellent quality which contributes greatly to production of good castings.

FRAMES

Rigid, Calculation of. A New Calculating Method for Rigid Frames (Ein neues Berechnungsverfahren für biegungsfeste Rahmen nach H. Bronneck), H. Marx. Dinglers polytechnisches Jl., vol. 336, no. 21, Oct. 22, 1921, pp. 301–302, 2 figs. Describes new method by Hugo Bronneck, with which, it is claimed, calculation of most complicated frame forms (for which few or no formulas exist) can be made without referring to formulas or making new derivations.

FREIGHT HANDLING

Electric Apparatus for. Electrically Operated Apparatus for Handling Railway "General Goods," George Bulkeley. Electrician, vol. 87, no. 2276, Dec. 30, 1921, pp. 819–821, 3 figs. Discusses principle of loading general merchandise; limitations of overhead gantry crane; electric platform trucks; etc.

FUELS

America's Resources. America's Fuel Resources, Robert G. Skerrett. Sci. Am., vol. 126, no. 2, Feb. 1922, pp. 86–87, 3 figs. Data on deposits and consumption. Presents charts showing how consumption of petroleum and coal has increased since 1880.

Gaseous Products, Composition of. Formulas for the Control of Gas Composition in Combustion and Gasification Processes and for the Calculation of Air and Exhaust-Gas Volumes (Formeln für die Kontrolle der Gaszusammensetzung bei Verbrennungs- und Vergasungsvorgängen und für die Berechnung der Luft- und Abgasmengen), Gustav Neumann. Stahl u. Eisen, vol. 41, no. 50, Dec. 15, 1921, pp. 1811–1817. Relations between chemical composition of fuels and chemical composition of the gaseous products resulting from their combustion, carbonization or distillation, are numerically determined and expressed in closed formulas.

Ignition Temperatures. The Ignition Points of Fuels According to Recent Tests (Die Zündpunkte von Brennstoffen nach neueren Versuchen), E. Daiber. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 50, Dec. 10, 1921, pp. 1289–1290, 3 figs. Account of tests on ignition temperatures of liquid and solid fuels. Notes on apparatus used, influence of time on ignition point, values and other results obtained. Comparison of described processes of Moore and Hawkes.

FURNACES

Oxy-Acetylene. An Oxygen-Acetylene High-Temperature Furnace, Hewitt Wilson. Am. Ceramic Soc. Jl., vol. 4, no. 10, Oct. 1921, pp. 835–841, 2 figs. Detailed description to show use of oxy-acetylene gas in a small furnace for using refractory cones. Advantages of furnace.

FURNACES, BOILER

Solid and Liquid Fuels. The Pace Patent Furnace Door. Iron & Coal Trades Rev., vol. 103, no. 2808, Dec. 23, 1921, p. 917, 1 fig. Describes furnace for burning alternatively solid or liquid fuels and gives comparison of cost.

FURNACES, HEATING

Ingot-Reheating. Ingot Reheating Furnace, H. E. Smythe. Iron Age, vol. 109, no. 2, Jan. 12, 1922, pp. 149–150, 1 fig. New design to avoid imperfect and unequal heating by proper control of incoming gases.

FURNACES, INDUSTRIAL

High-Pressure Gas System. High Pressure Gas and Its Application to Industrial Furnaces, F. J. Evans. Am. Soc. for Steel Treating Trans., vol. 2, no. 3, Dec. 1921, pp. 213–222, 7 figs. Discusses low-pressure air and gas system with two-valve control and manual proportioning, and with single-valve control and automatic proportioning, and high-pressure gas system with single-valve control and automatic proportioning.

G

GAS PRODUCERS

Corrosion of Cooling System. Corrosion of a Producer-Gas Cooling System, Lloyd E. Jackson. Chem. & Met. Eng., vol. 26, no. 2, Jan. 11, 1922, pp. 60–64, 5 figs. Cooling water of high acidity and containing much dissolved oxygen and suspended coke dust causes deterioration of cooling system at plant of Providence Gas Co., Providence, R. I. Remedial measures are suggested

Tests with Alberta Coals. Gas Producer Trials with Alberta Coals, John Blizard and E. S. Malloch. Canadian Dept. of Mines, Bul. no. 33, 1921, 40 pp., 23 figs. Tests were carried out in Westinghouse, double-zone, gas producer. Aim of trials was to ascertain suitability of the various fuels for giving a clean combustible gas when burned in the producer. Results show that all fuels except one are suitable but that less than one-half can be recommended for continuous operation in producer.

GAS TURBINES

Efficiency, Determination of. The Thermodynamic Principles for Determination of the Expected Efficiency of Gas Turbines (Die thermodynamischen Grundlagen für die Bestimmung des von Gasturbinen zu erwartenden Wirkungsgrades), H. Schmolke. Zeit. für Dampfkessel u. Maschinenbetrieb, vol. 44, no. 44, Nov. 4, 1921, pp. 351–354, 4 figs. Review of works on this subject which have appeared in last ten years. Presents diagrams developed by W. Schule showing process and efficiency of Holzwarth turbines.

Impulse Type. Prospects of the Gas Turbine in Competition with Other Prime Movers (Die Aussichten der Gasturbine im Wettbewerb mit unseren bisherigen Kraftmaschinen), Hans Kasparek. Oel- u. Gasmaschine, vol. 18, nos. 8, 9, 10 and 11, Aug., Sept., Oct. and Nov. 1921, pp. 121–123, 142–146, 161–164 and 177–179, 5 figs. Notes on impulse gas turbines with turbo-compressors, piston compressors, etc.

GASES

Pump and Mixer. The Roturbo Gas Pump and Mixer. Engineer, vol. 132, no. 3444, Dec. 30, 1921, p. 704, 1 fig. Describes Rees Roturbo gas pump and mixer for creating a very intimate mixture between gases and liquids and so effecting required solution or chemical action in smallest possible time and space. It is designed to draw large volumes of gas from comparatively low vacuum and to mix them with the entraining liquid.

GEAR CUTTING

Broaching Machine. Gear Cutting or Broaching Machine. Eng. Production, vol. 3, no. 65, Dec. 29, 1921, p. 621, 1 fig. Patented method of producing gears, circular cutters, saws, etc., particularly adapted for manufacture on extensive basis, chief feature being cutting of number of teeth simultaneously.

Spur-Gear Machine. Cutting Spur Gears on the Shaper. Eng. Production, vol. 3, no. 64, Dec. 22, 1921, p. 587, 1 fig. Describes new gear-cutting attachment for generation of spur gears having correct tooth form, no matter what the number of teeth

GEARS

Involute. Design of Bevel, Helical and Worm Involute Gears, A. B. Cox. Am. Mach., vol. 56, no. 3, Jan. 19, 1922, pp. 104–107, 8 figs. Application of data of author's previous articles. Determination of helix and tooth angles. Relation between interference, number of teeth and sliding action.

The Evolution of the Involute Gear Tooth—X, A. Fisher. Machinery (Lond.), vol. 19, no. 483, Dec. 29, 1921, pp. 380–384, 6 figs. Discusses relation between tooth depth and thickness; backlash; generating teeth of conjugate thickness.

Tooth Shape. Gear Tooth Shape and Its Relation to Standardization, E. W. Miller. Automotive Industries, vol. 45, no. 24, Dec. 15, 1921, pp. 1167–1173, 26 figs. Discusses properties of involute form of gear tooth. True involute teeth with a certain pressure angle and relation between addendum and diametral pitch will not interfere with pinions down to 12 teeth. Such a system would facilitate universal interchangeability. Condensed from paper read before Am. Gear Manufacturers' Assn.

Worm. Worm Gear Generator. Machy. (Lond.), vol. 19, no. 481, Dec. 15, 1921, pp. 325–327, 9 figs. Describes in detail machine built by Smith & Coventry, Ltd., Manchester.

GIRDERS

Bending Moments. Graphic Determination of Bending Moments in a Girder Supporting Traffic Loads by Means of Cross Bars (Détermination Graphique des moments fléchissants maxima dans une poutre supportant des charges mobiles par l'intermédiaire des traverses), Smoukovitch and Barbillion. Le Génie Civil, vol. 79, no. 25, Dec. 17, 1921, pp. 533–535, 5 figs.

GRAIN ELEVATORS

Explosions. The Northwestern Elevator Explosion, David J. Price. Jl. Western Soc. of Engrs., vol. 26, no. 12, Dec. 1921, pp. 401–417 and (discussion) 417–419, 7 figs. Discusses in detail damage done to elevator operated by Armour Grain Company, South Chicago; theories advanced as to cause of explosion; lessons to be learned from the explosion; recommendations.

Pneumatic. Pneumatic Grain Elevators, R. E. Knight. Engineering, vol. 112, no. 2921, Dec. 23, 1921, pp. 864–866, 1 fig. Deals with pneumatic discharge of grain from ships, and more particularly with two modern examples of floating and quay-side plants in which oil engines or motors, and high-speed rotary exhausters, have replaced vertical or horizontal compound steam engines and reciprocating exhausters, as main power plant of installation. Paper read before Instn. Mech. Engrs. (British). See also Engineer, vol. 132, no. 3443, Dec. 23, 1921, pp. 685–687, 1 fig.

GRINDING

Differential Spider Arms. Grinding Differential Spider Arms, Charles Kotersall. Am. Mach., vol. 55, no. 25, Dec. 22, 1921, pp. 1009–1010, 3 figs. Method which eliminates use of centers and an inspection gage for insuring accuracy in alignment.

Surface. Why Work Curls Towards the Wheel While Being Surface Ground, E. A. Dixie. Am. Mach., vol. 55, no. 25, Dec. 22, 1921, pp. 1006–1007, 4 figs. Plausible theory deduced from long experience. Work heated beyond critical point in numberless places takes permanent set when quenched by coolant.

GRINDING MACHINES

Railroad Shops. The Grinding Machine in the Railroad Shop, Frank A. Stanley. Am. Mach., vol. 56, no. 2, Jan. 12, 1922, pp. 64–65, 10 figs. Advantages of grinding for finishing parts to size. Grinding operations on locomotive parts. Increasing efficiency of motion mechanism.

H

HANDLING MATERIALS

German Mechanical Devices. Development of Mechanical Handling Devices in Germany during and since the War, George F. Zimmer. Eng. & Indus. Management, vol. 6, nos. 18, 22, 24 and 26, Nov. 3, Dec. 1, 15 and 29, 1921, pp. 514–515, 1 fig.; 645–646, 2 figs.; 706–707, 7 figs. and 760–761, 1 fig. Information resulting from author's visit to German industrial centers. Points out that band conveyor has been superseded by other devices owing to high cost of bands. Nov. 3: Improved automatic colliery tippler. Dec. 1: Mechanical removal of ashes from locomotives. Dec. 15: Latest developments in coal-face conveyors. Dec. 29: Pneumatic handling.

Textile Mills. Material Handling in the Textile Industry, R. M. Gates. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 13–17, 8 figs. Shows types of electric trucks, belt conveyors, gravity conveyors, inclined elevators, etc., employed in textile mills. Points out importance of material handling.

HEAT

Recovery from Earth. Ground Heat as the Most Important Source of Energy (Die Erdwärme als wichtigste Energiequelle). Rauch u. Staub, vol. 12, no. 3, Dec. 1921, pp. 16–18. Review of developments in study of the recovery of heat from earth interior for technical purposes.

HEAT BALANCE

Electric Plants. Heat Balance of the Connors Creek Plant of the Detroit Edison Company, C. Harold Berry and F. E. Moreton. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 22–25, 8 figs. Describes briefly apparatus in plant, followed by discussion of ideal operating conditions, and presents actual results. Includes table showing thermal balance sheet for April 1921.

HEAT INTERCHANGERS

Experiments With. Experiments with Heat Interchangers, F. Russell Bichowsky. Jl. Indus. & Eng. Chem., vol. 14, no. 1, Jan. 1922, pp. 62–64, 3 figs. Discusses the Linde, Hampton, and Nelson types of interchangers.

HEAT PUMPS

Evaporators With. Experiences on Evaporators with Heat Pumps, E. Wirth. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 49–51, 5 figs. Points out that whereas until now investigations have been made only with regard to liquids with low-boiling point, data are now available on heavier liquids. Account of author's experiences with heat pump operation. Translated from Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 46, Nov. 12, 1921, pp. 1183–1186.

HEAT TRANSMISSION

Problems. Heat Transfer, W. H. McAdams and T. H. Frost. Jl. Indus. & Eng. Chem., vol. 14, no. 1, Jan. 1922, pp. 13–18, 2 figs. Problems arising in the field of heat transfer and rational method for studying them. Results of preliminary experiments to determine numerical value of coefficient of heat transfer between condensing vapors and a pipe.

HEAT TREATING

Plant Operation. The Complete Operation of a Modern Heat Treat Department, Thomas B. Fordham. Factory, vol. 28, no. 1, Jan. 1922, pp. 31–34, 6 figs. Method of control which has been successful in reducing scrap loss and bringing down manufacturing cost.

HEATING, ELECTRIC

Hot-Water. Comparative Investigations of Domestic Heating and Cooking Arrangements (Vergleichende Untersuchungen an häuslichen Heiz- und Kocheinrichtungen), J. Rutishauser and P. Schläpfer. Schweiz. Elektrotechnischer Verein Bul., vol. 12, nos. 10, and 12, Oct. and Dec. 1921, pp. 259–270 and 376–406, 27 figs. Oct.: Comparative tests on hot-water installations with coke and electric heating. Dec.: Comparative tests on different cooking devices, and comparative cooking tests with a coal oven and electrically heated tipping boilers in the Claradel Sanatorium, Zürich, Switzerland.

HEATING, FACTORY

Bleeder Steam. Using Bleeder Steam in Factory Heating, J. A. McGilvray. Power House, vol. 14, no. 22, Nov. 21, 1921, pp. 21–27, 11 figs. Bleeder type is especially furnished where low pressure steam is required for heating, in combination with electric motive power. Bleeder types are designed for a variety of conditions of operation, both in condensing and non-condensing units, or any combination of the two.

HEATING, STEAM

Central-Station. Present State of Central Heating Station Practice (La technique actuelle des centrales à vapeur). Le Génie Civil, vol. 79, no. 21, Nov. 19, 1921, pp. 433–437. Discusses report of Commission for Utilization of Fuels, types of boilers, economizers, superheating, pre-heating, feedwater, etc. From Journal Officiel.

Equipment. Features of Central Steam Heat Plant Equipment, W. A. Scott. Elec. Rev., (Chicago), vol. 79, no. 21, Nov. 19, 1921, pp. 759–760, 1 fig. Underfeed stokers provide for boiler operation at 250 per cent of rated capacity; modern coal and ash handling apparatus reduces operating labor; water softener used to treat well water.

Exhaust. House Heating with Exhaust Steam (Raumheizung durch Abdampf), W. Pauer. Archiv für Wärmewirtschaft, vol. 2, no. 10, Oct. 1921, pp. 128–130, 2 figs. Gives fundamental principles for economic arrangement of heating installations, and discusses useful scope of the three types, namely, back-pressure, discharge and condensation.

Heat Utilization. Economic Utilization of Heat in Steam-Heating Plants (Wirtschaftliche Wärmeausnutzung bei Zentralheizungen), H. Fradel. Zeit. für Dampfkessel u. Maschinenbetrieb, vol. 44, nos. 40, 42–43 and 44, Oct. 7, 28 and Nov. 4, 1921, pp. 324–327, 342–344 and 355–357, 24 figs. Review of latest developments in steam-heating plants. Reconstruction of steam heaters in dwelling houses.

HOISTS

Electric. Choice of Angular Velocity of a Winding Engine Driven by a Three-Phase Asynchronous Motor (Du choix de la vitesse angulaire d'une machine d'extraction commandée par moteur asynchrone triphasé), Georges Hacault. Révue Générale de l'Électricité, vol. 10, no. 22, Dec. 3, 1921, pp. 813–816, 2 figs. Discusses angular velocity from the point of view of slowing down without loss of energy or mechanical braking.

Mine. Scraping and Loading in Mines With Small Compressed-Air Hoists, Ward Royce. Eng. & Min. Jl., vol. 112, nos. 24, 25 and 26, Dec. 10, 17 and 24, 1921, pp. 925–931, 973–977 and 1014–1019, 50 figs. Use of slushers in underground loading applicable to various mining methods. Types of scrapers in successful use in Joplin and Lake Superior iron and copper districts, and their application.

HYDRAULIC TURBINES

Bavarian Installations. The Turbines of the Walchensee Plant, Bavaria (Die Turbinen des Walchenseewerks), Georg v. Troeltsch. Elektrotechnische Zeit., vol. 42, no. 47, Nov. 24, 1921, pp. 1351–1354, 5 figs. Preliminary report of hydraulic equipment of unfinished plant in Bavaria. Turbines of total output of 168,000 hp. are being installed, two different types being used in same station, namely, four 24,000-hp. 500-r.p.m. Francis spiral turbines and four 18,000-hp. 250-r.p.m. Pelton wheels, both types operating under head of about 195 m. Comparison of described turbines with others of Francis and Pelton types.

Castings Making. Making Water Turbine Castings, H. E. Diller. Foundry, vol. 49, nos. 22 and 23, Nov. 15 and Dec. 1, 1921, pp. 873–878 and 920–925, 19 figs. Nov. 15: Describes molding the large scroll-case castings; skeleton patterns keep down expense of equipment. Dec. 1: Method of molding small runners with vanes of curved steel plate and larger sizes with cast-iron vanes.

Efficiency, Determination of. Calorimetric Determination of Efficiency of Hydraulic Turbines (Sur la détermination de rendement des turbines hydrauliques par voie calorimétrique), L. Barbillion and A. Poirson. La Houille Blanche, vol. 20, no. 57–58, Sept.-Oct. 1921, pp. 161–166, 2 figs. Discusses the Rappel method of determining efficiency, based on the transformation into heat of all power losses.

Impulse Type. Caribou Power Plant Has World's Largest Impulse Wheel, W. M. White. Jl. Electricity & Western Industry, vol. 47, no. 12, Dec. 15, 1921, pp. 465–466, 4 figs. Describes machinery installed in Caribou plant of Great Western Power Co., having normal capacity of 30,000 hp. each under 1008-ft. head, at 171 r.p.m.

Reaction. Hydraulic Reaction Turbines, D. J. McCormack. Elec. Jl., vol. 19, no. 1, Jan. 1922, pp. 11–16, 13 figs. Discusses runners, casing, bearings, shaft, gate mechanism, etc.

Recent Developments. High Speed Hydraulic Turbines (Om snabblöpande vattenturbiner). Teknisk Tidskrift (Mekanik), vol. 51, no. 12, Dec. 14, 1921, pp. 155–160, 18 figs. Discusses recent developments in design, especially profile, to increase degree of efficiency.

HYDRAULICS

Eddy Curves. New Method for the Determination of Eddy Curves (Nouvelle méthode pour la détermination des croubes de remous), E. Baticle. Le Génie Civil, vol. 79, nos. 23 and 24, Dec. 3 and 10, 1921, pp. 488–492 and 515–516, 7 figs. Reviews methods in use and develops formulas for an improved method which tests made show to be satisfactory.

Laboratory. The Hydraulic Laboratory, S. G. Roberts. Sci. Am., vol. 126, no. 1, Jan. 1922, pp. 10–11, 5 figs. Describes equipment and experimental work done at hydraulic laboratory at Petty's Island, Pa.

HYDROELECTRIC PLANTS

England. Nidd Valley Hydro-Electric Installation. Engineering, vol. 112, no. 2920, Dec. 16, 1921, pp. 817–818, 18 figs. partly on supp. plate and p. 824. Small hydroelectric plant built for purpose of supplying power for cranes, wire ropeways crushing plant, etc., to be employed in construction of new Scar House dam. See also Elec. Rev. (Lond), vol. 89, no. 2299, Dec. 16, 1921, pp. 810–812, 5 figs.; and Elec. Times, vol. 60, no. 1574, Dec. 15, 1921, pp. 531–533, 4 figs.; also Engineer, vol. 132, no. 3442, Dec. 16, 1921, pp. 639–641, 10 figs. partly on p. 650.

Silt-Removal Plants. Silt-Removal Plants for Hydroelectric Stations (Entsandungsanlagen nach Patent H. Dufour). Schweizerische Bauzeitung, vol. 78, nos. 25, 26 and 27, Dec. 17, 24 and 31, 1921, pp. 295–299, 310–312 and 323–325, 13 figs. Describes automatic and continuous silt-removal system patented by H. Dufour. Experience with sedimentation tanks, reconstructed according to described system, of hydroelectric plant supplying light and power to Santiago de Chile. Its employment in Swiss plants. Its effect on efficiency and economy of hydroelectric plants.

Storage Reservoirs. Hydroelectric Plants and Storage Reservoirs (Impianti idroelettrici e serbatoi), Aristide Zenari. Giornale dell'Associazione Nazionale degli Ingegneri Italiani, vol. 2, no. 14, Sept. 1, 1921, pp. 210–213, 1 fig. Discusses variation in water level and makes calculations.

I

ILLUMINATION

Calculation of Intensities. Illumination Calculations for Various Planes, J. H. Kurlander. Elec. Rev. (Chicago), vol. 79, no. 24, Dec. 10, 1921, pp. 885–887, 3 figs. Derivation of equation showing simple relations between illumination intensities, source candlepower, and dimensions that can be easily determined in the field or from room plans.

Factory. Factory Illumination. Eng. Production, vol. 3, no. 63, Dec. 15, 1921, pp. 570–571. Notes on installation of lighting systems. Discusses varieties of glass used for windows of industrial works, and different systems of artificial lighting, consisting of direct, semi-direct and indirect lighting.

INDICATORS

Steam-Engine. The Detection of Errors in the Steam-Engine Indicator. Power, vol. 55, no. 3, Jan. 17, 1922, pp. 103–105, 5 figs. Deals with most probable errors.

INDUSTRIAL MANAGEMENT

Factories. Technical Service at the Factory (Les Services d'études dans les usines), Emm. La Langlois. La Vie Technique et Industrielle, vol. 3, no. 26, Nov. 1921, pp. 132–133. Preparation of new installations; improvements in material, tools and processes; study of upkeep and repairs; filing of information and documents on all matters.

Gantt Charts. How a Manager Uses Gantt Charts, Frank W. Trabold. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 28–30. Discusses use of the Gantt load, idleness-expense, and man-record charts, some things they disclosed, and their value to executive.

Inspection System. The Delco Inspection System—II and III. Machinery (Lond.), vol. 19, nos. 473 and 475, Oct. 20 and Nov. 3, 1921, pp. 71–75, 14 figs. and pp. 122–125, 12 figs. Typical examples of gaging fixtures used by Dayton Engineering Laboratories Co. in manufacture and inspection of company's product.

Planning. Departmental Collaboration, James Edgar. Eng. & Indus. Management, vol. 6, no. 24, Dec. 15, 1921, pp. 690–692. Explains scientific planning of output, which has become essential with introduction of quantity-producing methods, consequent upon development of automatic machine.

Process Charts. Process Charts and Their Place in Management, Frank B. and L. M. Gilbreth. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 38–41 and 70, 4 figs. Device for visualizing process as means of improving it. Authors point out place of process chart in management and present established working data used successfully in numerous working installations for many years; also its simplicity, field of application, its relation to standardization, etc.

Production Order Quantity. Determining the Production Order Quantity, W. E. Camp. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 17–18, 2 figs. Writer derives formula for determining production order quantity such that total cost per unit for

setting up plus interest on stores investment will be minimum.

Routing. A Term-Delivery System (Ein Terminabgabesystem), H. Hempel. Werkstattstechnik, vol. 15, no. 20, Oct. 15, 1921, pp. 600–605, 10 figs. Describes practical tried-out system for term delivery. Routing of work is carried out from a central office in close touch with all employees.

Service Department. Service Work As a Phase of Production, S. Harold Greene. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 7–11. Outlines system of service work which, it is claimed, should be recognized as a necessary and integral part of production.

Stores Control. Some Notes on Stores Control. Eng. & Indus. Management, vol. 6, no. 24, Dec. 15, 1921, pp. 682–684, 2 figs. Notes on systematic recording and disposal of defective parts.

Small Factories. Management Problems of the Small Factory, Ernest Cordeal. Indus. Management, vol. 63, no. 1, Jan. 1922, pp. 43–49, 2 figs. Machines, tools and appliances.

Organization and Management of the Small Shop, E. W. Leach. Am. Mach., vol. 55, nos. 17, 19 and 22, Oct. 27, Nov. 10 and Dec. 1, 1921, pp. 671–673, 754–756 and 883–885. Oct. 27: Small shop office work; why bookkeeping is essential; classifications of entries; value of credit. Nov. 10: Going after business; cause and effect of readjustment; function of advertising. Dec. 1: Qualifications of successful executive; coöperation between producers and management; modern business ethics.

Tool-Engineering Department. How Tool Engineering Cuts Costs, Joseph Lannen. Indus. Management, vol. 63, no. 1, Jan. 1922, pp. 12–20, 9 figs. System of supervising jigs, fixtures, gages and other equipment. Describes methods that have given satisfactory results in process of ascertaining costs in tool-engineering department.

Workshops. Workshop Management (Le controle à l'atelier), C. B. Thompson. L'Outillage, vol. 234, no. 46, Nov. 17, 1921, pp. 1232–1233. Discusses scientific management and its various applications.

[See also TAYLOR SYSTEM; TIME STUDY.]

INDUSTRIAL ORGANIZATION

British Works. An Efficient Works System. Eng. Production, vol. 3, nos. 60, 61, 62, Nov. 24, Dec. 1, 8 and 15, 1921, pp. 493–498, 517–522, 539–544 and 557–562, 59 figs. Detailed description of successful organization and system in works of Barr & Stroud, Ltd., Glasgow, manufacturers of high-grade precision instruments.

Knitting Mill. The Organization of Knitting Mills, Carle M. Bigelow. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 37–42, 5 figs. Solving problem of labor control.

INDUSTRIAL RELATIONS

Human Factor. The Human Factor in Industry—IV, Clarence H. Northcott. Indus. Management, vol. 63, no. 1, Jan. 1922, pp. 36–41. What industry owes workers as members of the community. Notes on wage principles; rate fixing; organization to guarantee fair wages; security against unemployment; work preparatory school; care for working conditions; vocational selection; etc.

Improvement of. Various Plans to Improve Industrial Relations, Ray Vance. Can. Foundryman, vol. 12, no. 8, Aug. 1921, pp. 32–35. Discusses human elements, stock selling plans, bonus plans, industrial democracy, shop committee plans, etc.

Workmen's Control. The Workman in Control (Le Contrôle ouvrier). La Métallurgie, vol. 53, no. 46, Nov. 17, 1921, pp. 2141–2142. Discusses attitude of workers, industrial democracy, consent of labor, etc.

INDUSTRIAL TRUCKS

Electric. The Electromobile. Motor Transport, vol. 33, no. 879, Jan. 2, 1922, p. 13, 3 figs. Describes a battery-propelled vehicle of the 1 and 2-ton and the 4 and 5-ton types, the latter having a four-wheel drive.

INTERNAL-COMBUSTION ENGINES

Compound. Compounding the Combustion Engine, Elmer A. Sperry. Mech. Eng., vol. 44, no. 1, Jan. 1922, pp. 27–32 and 74, 14 figs. Presents results of research by author extending over series of years, during which it is claimed that not only has high-pressure principle been thoroughly established, but all important requirements have been worked out, and an engine embodying practically all advantages has been subjected to long continuous runs.

Development. Internal Combustion Engine, Charles E. Lucke. Nat. Engr., vol. 25, no. 12, Dec. 1921, pp. 604–607. Rising importance of oil-injection type. Review of development.

Working Process. The Working Process of Internal-Combustion Engines (Die Darstellung des Arbeitsvorganges der Brennkraftmaschinen), P. Meyer. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 48, Nov. 26, 1921, pp. 1234–1238, 7 figs. Writer points to defects of temperature-entropy diagram for representation of heat movement in internal-combustion engines, and describes a method for making the same determinations without employment of the terms entropy and kilogram-molecule, by sole use of well-known technical measurement units, and of presenting them in uniform dependence on volumetric value.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES; SEMI-DIESEL ENGINES.]

IRON

Electrolytic. Electrolytic Iron a Commercial Product, Bradley Stoughton. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 32–36, 5 figs. Éustis process compared with others. An ore instead of scrap as anode. Tests and properties, fields of usefulness.

IRON ALLOYS

Iron-Carbon. Study of Iron-Carbon Alloys (Zur Kenntnis der Eisen-Kohlenstofflegierungen), Rudolf Ruer. Zeit. für anorganische u. allgemeine Chemie, vol. 117, no. 4, July 27, 1921, pp. 249–261, 4 figs. Notes on solubility of cementite in molten iron; complete equilibrium between austenite, ferrite and graphite corresponding to equilibria of pearlite.

IRON AND STEEL

Production Cost, China. Cost of Iron and Steel Production in China. Colliery Guardian, vol. 122, nos. 3167 and 3168, Sept. 9 and 16, 1921, p. 714 and p. 818. Sept. 9: Gives tables of monthly figures of Hanyang and Penghsihu works and discussses them. Sept. 16: Gives cost of steel manufacture, and cost and labor. Concludes that cost of iron and steel production in China cannot be lowered unless there are better and cheaper means of transportation. From Peking Daily News.

L

LABOR

Eight-Hour Laws. The Eight-Hour Day (Autour de la journée de huit heures), Georges Lafond. L'Outillage, vol. 232, no. 44, Nov. 3, 1921, pp. 1165–1167. Discusses conditions in France and other countries, showing that it cannot be maintained.

Rules for Railway Shop Crafts. New Rules for Shop Crafts Issued by Labor Board. Ry. Mech. Engr., vol. 96, no. 1, Jan. 1922, pp. 9–16. Gives complete text of new rules, including special rules for each craft. Provisions made more elastic; rights of minorities recognized; many old rules retained.

LABORATORIES

Research. Finding the Better Way—III, Charles E. Ruby. Indus. Management, vol. 63, no. 1, Jan. 1922, pp. 26–29, 3 figs. How research laboratories assist business. Users of industrial laboratories.

LATHES

Capstan. A 5¼-Inch Capstan Lathe. Engineer, vol. 132, no. 3443, Dec. 23, 1921, pp. 684–685, 4 figs. Describes new design of lathe by Pollock & Macnab, Ltd., Bredbury, England, which is said to be much more powerful than lathes of this size usually are.

Turret. Turret Lathe Tooling, I. F. Yeoman. Machy. (N. Y.), vol. 28, no. 5, Jan. 1922, pp. 356–358, 4 figs. Equipment for machining differential gear housings on foster turret lathes.

LEAD ALLOYS

Frary Metal. The Electrolytically Produced Calcium-Barium-Lead Alloys Comprising Frary Metal, William A. Cowan, L. D. Simpkins and G. O. Hiers. Chem. & Met. Eng., vol. 25, no. 26, Dec. 28, 1921, pp. 1181–1185, 13 figs. Equilibrium diagram and microstructure of barium-lead and calcium-lead alloys. Ternary alloy hardens and strengthens on aging; is hard at moderate temperature; can be melted without change in analysis, and is a very fine bearing metal. Paper, slightly condensed, read before Am. Electrochem. Soc.

LIFTING MAGNETS

Use in Workshops. Lifting Magnets and Their Use in Workshops (Die Lasthebemagnete und ihre Anwendung im Werkstättenbetriebe), Richard Hänchen. Betrieb, vol. 4, no. 5, Dec. 10, 1921, pp. 157–162, 13 figs. Discusses their useful field, operation and efficiency, and describes newest types.

LIQUIDS

Corrosive, Handling. Anti-Corrosive Chemical Engineering Plant. Canadian Chemistry and Metallurgy, vol. 5, no. 12, Dec. 1921, pp. 341–342, 2 figs. Some English chemical equipment designed for special service in handling acids and corroding liquids.

LOCOMOTIVES

Design. Modern Locomotive Engine Design and Construction—LXXVI. Ry. Engr., vol. 42, no. 503, Dec. 1921, pp. 458–463, 7 figs. Practical considerations affecting production of an economical form of coupling rod.

Electric. See ELECTRIC LOCOMOTIVES.

Missouri and Northern Pacific. Operating Capacity Increased With Modern Motive Power. Ry. Rev., vol. 69, no. 25, Dec. 17, 1921, pp. 817–824, 8 figs. Describes Mikado, Mountain, and Pacific types, constructed by Am. Locomotive Co. for Missouri and Northern Pacific roads.

Mountain Roads. Shay Geared Locomotives for Mountain Roads. Ry. Age, vol. 71, no. 25, Dec. 17, 1921, pp. 1198–1210, 4 figs. 150-ton Shay for Greenbriar, Cheat & Elk R. R. High sustained tractive effort compared with Mikados.

Rebuilding. Rebuilding Old Locomotives, Carl B. Smith. New England Railroad Club, Dec. 13, 1921, pp. 207–214 and (discussion) 215–228. Discusses replacing of boilers, superheater equipment, cylinders, valve gears, frames, automatic fire doors, and other parts.

Superheater. Locomotives of the Pacific Type of the Midi Company, France (Note sur les locomotives Pacific à deux cylindres à simple expansion et surchauffe de la Compagnie des Chemins de Fer du Midi), M. Leboucher. Révue Générale des Chemins de Fer et des Tramways, vol. 40, no. 11, Nov. 1921, pp. 291–303, 7 figs., partly on supp. plate. Superheater, two-cylinder twin-action type. Complete specifications and data.

LUBRICANTS

Reclamation and Distribution. Supplying Oil to 2,000 Automatic Screw Machines, E. C. Henn. Am. Mach., vol. 56, no. 1, Jan. 5, 1922, pp. 4–7, 10 figs. Oil pumped from tank cars to storage tanks; centrifugal machines separate used oil from chips; elaborate system of reclamation and distribution.

Viscosity and Friction. Viscosity and Friction, Winslow H. Herschel. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 31–41, 2 figs. Discusses viscosity effect in complete-film-lubrication régime; viscosity estimation at one temperature from observed viscosity at another temperature; friction testing of bearing metals; oiliness of lubricants; oil-friction testing machines; etc.

LUBRICATING OILS

Steam-Turbine. Essential Qualities of Oil for Steam Turbine Lubrication, J. Y. Dahlstrand. Elec. Rev. (Chicago), vol. 79, no. 21, Nov. 19, 1921, pp. 770–772, 3 figs. Definition of viscosity of oil; tests required to determine quality of oil; auxiliary oil pump and its operation and use.

The Viscosity of Steam-Turbine Oils, V. M. Hatch. Power, vol. 54, no. 26, Dec. 27, 1921, pp. 1011–1012. Factors controlling friction in bearings. Viscosity at operating temperature is said to be most important consideration.

M

MACHINE GUNS

Browning .50-Caliber. The Super-Machine Gun, Herbert O'Leary. Army Ordnance, vol. 2, no. 9, Nov.-Dec. 1921, pp. 129–132, 7 figs. Describes the Browning .50-caliber machine gun and its successful development.

MACHINE SHOPS

British. Famous British Works. Eng. Production, vol. 3, nos. 64 and 65, Dec. 22 and 29, 1921, pp. 578–580, 6 figs. and 602–604, 4 figs. Dec. 22: Describes Siemens Works, Stafford, of the English Elec. Co., Ltd., for manufacture of medium sizes of electrical equipment, particularly rotary converters for industrial purposes and electric traction, and switchgear of all kinds. Dec. 29: The Hoffmann Mfg. Co., Ltd., Chelmsford, for manufacture of ball and roller bearings.

MACHINE TOOLS

Drives. The Driving of Machine Tools, Hubert Bentley. Eng. & Indus. Management, vol. 6, no. 24, Dec. 15, 1921, pp. 688–689. Practical advice on efficient driving of modern machine tools. Deals with increased employment of chain and direct-gear drive in transmitting power, and advent of direct drive from lineshaft to single-pulley all-gear-driven machine.

Feeds and Speeds. Feeds and Speeds as Production Factors, Albert A. Dowd and Frank W. Curtis. Machy. (N. Y.), vol. 28, no. 5, Jan. 1922, pp. 381–383, 5 figs. Importance of recording; installing a system of and setting speeds and feeds; savings made possible by increasing rate of feed on a lathe; savings effected by change of tools.

MACHINERY

Special and Automatic. When Is It Economical to Install Special and Automatic Machinery? A. L. DeLeeuw. Management Eng., vol. 2, no. 1, Jan. 1922, pp. 19–24, 1 fig. Includes chart showing various conditions met in grouping special machinery. Notes on determining costs under part-time operation; figuring value of machinery; single-purpose machines; operating automatic machinery in cycles; etc.

MALLEABLE CASTINGS

Foundry Problems. Pertinent Facts Concerning Malleable-Iron Castings, Enrique Touceda. Soc. Automotive Engrs. Jl., vol. 10, no. 1, Jan. 1922, pp. 53–61, 12 figs. Discusses foundry difficulties; casting defects; shrinkage and machinability; improvements in annealing-oven construction and operation.

MANGANESE STEEL

Electric. Manganese Steel Made in Electric Furnace, Larry J. Barton. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 4–8 and 109, 11 figs. Discusses melting practice for castings. Use of manganese steel scrap. Deoxidizing with manganese ore. Heat treatment.

Welding. Welding Manganese Steel, H. R. Pennington. Welding Engr., vol. 12, Dec. 1921, pp. 21–23 and (discussion) 23–24, 2 figs. Frogs and crossing layouts put in service at a fraction of cost of new installation. Gives table showing effect of varying quantities of manganese and carbon on physical quality of steel. Discusses arc welding methods. Paper read before Am. Welding Soc.

MARINE STEAM TURBINES

Blading Failures. Low Pressure Turbine Blading Failures in Destroyers, D. F. Ducey. Jl. Am. Soc. Naval Engrs., vol. 33, no. 3, Aug. 1921, pp. 512–540, 39 figs. The turbines are of the impulsive type having five rows of moving blades. The first and second are of monel metal, the third, fourth and fifth of chrome-vanadium and chrome-nickel steel. Describes failures in detail and gives illustrations.

MATERIALS

Thermal Conductivity of Wearing. Thermal Conductivity of Some Wearing Materials, Emily S. Rood. Physical Rev., vol. 18, no. 5, Nov. 1921.

pp. 356–361. Results of measurements made with samples of woolen, cotton, and silk materials.

METALS

Colloidal State. Colloidal State in Metals and Alloys—I, Jerome Alexander. Chem. & Met. Eng., vol. 26, no. 2, Jan. 11, 1922, pp. 54–58. Molten metal. Shows that many of important phenomena of metals and alloys are due to colloidal state of subdivision, and that portion of the metal or alloy tends to remain in the colloidal state and exert a powerful influence upon physical properties of final solid magma.

Electrodeposition. The Electro-Deposition of Metals—VIII, W. E. Hughes. Beama, vol. 9, no. 6, Dec. 1921, pp. 555–562. Discusses electrodeposition of lead. Applications, properties, lead-plating solutions, and microstructure.

Fatigue. Fatigue of Metals Under Repeated Stress, Moore and Kommers. Chem. & Met. Eng., vol. 25, no. 25, Dec. 21, 1921, pp. 1141–1144, 6 figs. Results of experiments. Carbon steels will not fail by "fatigue" if stressed below a definite amount, quickly determined by measuring heat generated in specimen during test.

Grain Structure. Grain Structure in Metals (Ueber Faserstruktur bei Metallen), Margarete Ettisch, M. Polanyi and K. Weissenberg. Zeit. fur Physik, vol. 7, no. 3, Nov. 3, 1921, pp. 181–184, 4 figs. Investigation of hard-drawn copper and tungsten wires, results of which show crystallographic directions in which wires are grained.

Metallographic Testing. Metallographic Testing. U. S. Bur. of Standards Circular, no. 42, Aug. 29, 1921, 11 pp., 4 figs. Study of fundamental conditions, structure, constitution, and treatment of metals and alloys. Discusses different lines of metallographic testing carried out by Bur. of Standards.

Structure. Structure and Related Properties of Metals, U. S. Bur. Standards Circular, no. 113, Sept. 7, 1921, 104 pp., 71 figs. Discusses general nature of structure of metals, methods for revealing it, and dependence of properties of metal as a whole upon its structural features. Describes methods in use for revealing chemical unhomogeneity, crystalline heterogeneity, physical unsoundness, and mechanical nonuniformity. Discusses principles underlying action of etching reagents; conditions affecting structure, chemical composition, application of heat, and mechanical working of metal; and dependence of mechanical properties and chemical behavior upon structure condition of material.

Surface Flaws. Influence of Surface Flaws on Strength of Metals, Horace C. Knerr. Automotive Industries, vol. 45, no. 25, Dec. 22, 1921, pp. 1216–1217, 6 figs. Shows that surface flaws have a pronounced effect upon metals subjected to fatigue through repeated stresses, but that such flaws do not always decrease strength under constant load conditions.

Testing. Testing Metal by Repeated Stress, H. F. Moore and J. B. Kommers. Iron Trade Rev., vol. 69, no. 25, Dec. 22, 1921, pp. 1623–1630, 7 figs.; also Eng. News-Rec., vol. 88, no. 2, Jan. 12, 1922, pp. 76–78, 3 figs. Fatigue investigation is broadened to include variety of steels and several heat treatments. Results show definite relation between Brinell hardness and endurance limit. Rise of temperature test used to predict limit. (Abstract.) Bul. no. 124, Engineering Experiment Station, University of Illinois.

METRIC SYSTEM

English System vs. A Digest of "The Metric versus the English System of Weights and Measures." Nat. Indus. Conference Board, Special Report No. 20, Dec. 1921, 11 pp. Presents facts and arguments on whether metric system should be substituted for English system of weights and measures in the United States.

MILLING CUTTERS

Backed-Off. Backed-Off Milling Cutters (Ueber hinterdrehte Fräser), Paul Zietung. Werkstattstechnik, vol. 15, no. 20, Oct. 15, 1921, pp. 593–595, 32 figs. Notes on production of backed-off profile cutters with a forming tool and different separate tools in various relief stages; control of backed-off milling cutters. Discusses copying with backed-off milling cutters.

Sharpening. How to Sharpen Milling Cutters, Fred B. Jacobs. Abrasive Industry, vol. 2, no. 12, Dec. 1921, pp. 395–401, 19 figs. Cutter grinding operations are expedited by using a machine designed for the purpose; form cutters require careful attention.

MILLING MACHINES

Manufacturing Operations. Manufacturing Operations on Milling Machines, Robert Mawson. Am. Mach., vol. 55, no. 25, Dec. 22, 1921, pp. 996–997, 10 figs. Special toolholders for facing four-step cones. Fixtures and tools for machining milling machine heads. A unique angle-facing fixture.

MOLDING MACHINES

Modern Types. The Present Status of Molding Machine Construction—I (Der heutige Stand des Formmaschinenbaues), U. Lohse. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 48, Nov. 26, 1921, pp. 1229–1223, 17 figs. Deals with hand-molding machines, including machines with lifting carriages, stripping-plate machines, and turnover-type machines.

Rollover. Rollover Jarring Machines (Der Guttmannsche Umrollrüttler), U. Lohse. Giesserei-Zeitung, vol. 18, no. 32, Nov. 15, 1921, pp. 423–424, 1 fig. Machine constructed by A. Guttmann Machine Constr. Corp., Hamburg, is said to differ from American types in that all the movements (jarring, rolling over and taking out) are effected by a single pneumatic cylinder by means of a single regulating cock.

MOLDING METHODS

Flour-Mill Rolls. Molding and Casting Chilled Flour-Mill Rolls, G. O. Vair. Can. Foundryman, vol. 12, no. 8, Aug. 1921, pp. 20–21 and 25, 5 figs. Designs for molds; casting; machining.

MOLYBDENUM STEEL

Annealing. Constituents Observed in Tungsten and Molybdenum Steels (Constituants observés dans les aciers au tungstène et les aciers au molybdène), Albert Portevin. Révue de Métallurgie, vol. 18, no. 11, Nov. 1921, pp. 713–716, 6 figs. Effects of annealing and subsequent very slow cooling on structure. Paper read before Iron & Steel Inst., Paris.

MOTOR TRUCKS

Manufacturing Methods. Manufacturing Parts of Northway Trucks, Robert Mawson. Am. Mach., vol. 56, no. 3, Jan. 19, 1922, pp. 101–103, 10 figs. Work on pistons and connecting rods; turning and inspecting camshafts; crankshaft balancing; fixture for assembling chassis; pressing on rubber tires.

MOTORCYCLES

Single-Cylinder Solo. The Development of the Single-Cylinder Solo Motor Cycle, H. D. Teage. Automobile Engr., vol. 11, no. 156, Nov. 1921, pp. 382–386, 12 figs. Distinguishes between the luxurious go-anywhere touring mount, the purely sporting machine, and the machine for the multitude. Discusses weight, valve gear, two-cycle engines, cooling, lubrication, ignition, transmission, etc. Paper read before Instn. Automobile Engrs.

N

NOZZLES

Measuring Pulsating Flow. The Use of Nozzles in Measuring Pulsating Flow. Chem. & Met. Eng., vol. 26, no. 1, Jan. 4, 1922, pp. 32–34, 3 figs. Discusses errors resulting from use of nozzles for measuring differential pressure unless the flow curve is known as a function of time.

O

OIL ENGINES

High-Compression. The Recent Development of High-Compression Oil Engines Without Air Pumps, Especially As Small Oil Engines (Die neuere Entwicklung der Hochdruckölmaschine ohne Luftpump, insbesondere als Kleinölmaschine), F. Modersohn. Oel- u. Gasmaschine, vol. 18, nos. 9, and 11, Sept. and Nov. 1921, pp. 140–142, and 169–173, 2 figs. Deals only with such engines whose practicability has been demonstrated, which are divided into three groups, namely, those operating with pure pressure injection; with combustion-chamber action; and with eddy production.

Manufacturing Methods. Cutting Costs in a Crude-oil Engine Manufactory. Machy. (Lond.), vol. 19, no. 481, Dec. 15, 1921, pp. 315, 11 figs. Reviews methods employed by Vickers-Petters, Ltd., Ipswich, including machining component parts, operations on cylinder casing and cylinder liners, elimination of non-productive machine time, etc.

OIL FUEL

Burning. The Burning of Oil Fuel and the Arrangement of Machinery Necessary, together with Observations and Comments Drawn from Actual Conditions, A. Keens. Trans. Inst. Mar. Engrs., vol. 33, Oct. 1921, pp. 337–363 and (discussion) 363–375, 12 figs. Discusses advantages of fuel oil: storage spaces; oil fuel pumps; piping, holders and burners; furnaces and combustion chambers; pumping arrangement; etc.

Glass Industry. The Application of Oil Fuel in the Glass Industry. Jl. Soc. Glass Technology, vol. 5, no. 19, Oct. 1921, pp. 286–300 and (discussion) 300–307. Symposium. Comparison with gas firing.

Injection and Combustion. Injection and Combustion of Fuel-Oil—VI and VII, C. J. Hawkes. Motorship, vols. 6 and 7, nos. 10 and 2, Oct. 1921 and Jan. 1922, p. 820, 4 figs. and p. 34, 6 figs. Experiments with solid-injection and air-blast in marine Diesel engines.

Mexican. The Production and Combustion of Mexican Fuel Oil—VIII, J. M. Pettinbell and J. R. Carlson. Combustion, vol. 5, no. 6, Dec. 1921, pp. 254–257, 6 figs. Discusses economy in oil burning operation.

Steam Generation. Liquid Fuel and Its Application for Steam Generation, J. H. Anderson. Inst. of Mar. Engrs. Trans., vol. 33, Dec. 1921, pp. 521–563 and (discussion) 563–568, 27 figs. Discusses fractional and continuous distillation, and use of fuel oil. Describes a number of oil fuel heaters and systems of fuel-oil burning.

Sulphur in. Effects of Sulphur in Fuel Oil, Allen F. Brewer. Power, vol. 55, no. 2, Jan. 10, 1922, pp. 50–51. States that presence of sulphur is detrimental, but its deteriorating effect can be largely avoided by adopting proper precautions.

OILS

Vegetable, Machines for Producing. Machinery for Vegetable Oil Prodiction. Eng. Rev., vol. 35, no. 6, Dec. 1921, pp. 182–187, 8 figs. Reviews development of these machines and compares the various designs.

OPEN-HEARTH FURNACES

Fuels Used. Fuels Used in Open-Hearth Practice, Edwin F. Cone. Iron Age, vol. 108, no. 25, Dec. 22, 1921, pp. 1589–1591. Analysis of 1920 ingot and castings production. Producer gas chiefly employed for ingots and oil for castings. Results of answer to questionnaire sent to producers of open-hearth steel ingots and steel castings.

OXY-ACETYLENE WELDING

Bronze Condenser Sheets. Bronze Condenser Sheets, H. I. Walsh. Welding Engr., no. 12, Dec. 1921, pp. 27–28 and 40, 7 figs. Gas welding gives practical solution of problem arising from increase in size of ships. Paper read at Internat. Acetylene Assn. Convention.

P

PIPE, STEEL

Hammer-Welded. Hammer-Welded Steel Pipe—How It Is Made and Wherein It Excels. Raw Material, vol. 4, no. 11, Nov. 1921, pp. 384–391, 11 figs. Discusses advantages over butt-weld and lap-weld methods, and methods used by Nat. Tube Co.

PIPE, WROUGHT-IRON

Chart for. Wrought Pipe Data. Sanitary & Heat. Eng., vol. 96, no. 14, Dec. 30, 1921, p. 395. Chart containing valuable information for the sanitary and heating engineer.

PISTONS

Machining Castings and Rings. How a British Foundry Specializes, H. Cole Estep. Foundry, vol. 49, no. 22, Nov. 15, 1921, pp. 879–887, 22 figs. Describes English methods of making piston castings and pots for piston rings.

PLANERS

Testing. Planing Machine Studies. Engineering, vol. 112, no. 2922, Dec. 30, 1921, p. 886. Results of experimental work carried out in Germany by G. Schlesinger on a horizontal planing machine, driven by electric motor running at 1460 r.p.m. with toothed gear and belting. Various improvements were tested and it was possible to greatly reduce power absorbed and almost completely overcome power fluctuations. Translated from pamphlet by G. Schlessinger and M. Kurrein.

POWER

Costs. How to Follow Up Power Costs—III, N. A. Craigue. Indus. Management, vol. 63, no. 1, Jan. 1922, pp. 55–59, 1 fig. Various methods of distribution. Meters may be used to actually measure power as consumed; cost rate applied, and final cost obtained is charge against product.

POWER PLANTS

Design. Developments in Power Station Design. Engineer, vol. 132, nos. 3441, 3443 and 3444, Dec. 9, 23 and 30, 1921, pp. 613–614, 5 figs., partly on supp. plate.; 668–669, 3 figs.; 702–704, 10 figs. Dec. 9: Describes extensions being made to boilerhouse of the Neasden power station of Metropolitan Ry. by John Thompson Water-Tube Boilers, Ltd., Wolverhampton. Dec. 23: 12,000-kw. turbo-generator installed at Neasden power station, and other important additions. Dec. 30: Application of air heaters to central-station boilers.

Modern European Tendencies in Power-Plant Design, A. W. H. Griepe. Power, vol. 55, no. 2, Jan. 10, 1922, pp. 54–56. European tendency is now to supply large cities at high voltage from large generating stations near mines, and gradually to shut down small, inefficient local plants. Notes on modifications in boiler proportions, types of boilers in use, boiler tubes and superheaters, economizers, stokers, cinder and soot disposal, preheating of air, use of low-grade fuels, etc. The Bone-Schnabel surface-combustion process in Germany. Only horizontal types of turbines used.

Maxim Silencers, Use of. The Maxim Silencer in the Power Plant. Power, vol. 55, no. 3, Jan. 17, 1922, p. 91, 3 figs. Describes use of such silencers, patents for which are now pending, as power-plant apparatus, for application to exhausts of oil and gas engines, oil- and gas- engine suctions, compressed-air unloaders, unaflow-engine exhausts, steam safety valves, air hoists, steam and air discharges from special apparatus.

Progress in 1921. The Year's Progress in the Power Plant Field. Power, vol. 55, no. 1, Jan. 3, 1922, pp. 2–14, 11 figs. Boiler efficiencies of 90 per cent when burning pulverized coal, seven notable steam plants put into operation, unusual interest in hydroelectric development, 220,000-volt electric power equipment, are some of outstanding features of 1921.

PRESSES

Hydraulic and Hand-Forcing. Hydraulic and Hand Forcing Presses in a Locomotive Shop, J. V. Hunter. Am. Mach., vol. 56, no. 3, Jan. 19, 1922, pp. 108–109, 5 figs. Horizontal press for forcing brasses in boxes. Method of using air pumps for boosting pressures. Self-contained portable press.

Fixtures. Some Examples of Fixtures Used on Profiling Machines, J. M. Henry. Am. Mach., vol. 55, no. 26, Dec. 29, 1921, pp. 1040–1043, 11 figs. Points out that with suitable fixtures, machines may be used for many different operations; and two or more operations may be preformed at one setting.

PULVERIZED COAL

Air Furnaces. Apply Powdered Coal to Air Furnace, Pat Dwyer. Foundry, vol. 49, no. 24, Dec. 15, 1921, pp. 955–962, 15 figs. Malleable-iron melting furnaces and annealing ovens have been converted

from hand-firing to use of powdered coal without involving radical changes in design.

Application to Boilers. Application of Pulverized Coal to Boilers, J. W. Fuller. Trans. Am. Inst. Min. & Metallurgical Engrs., no. 1106–C, 1921, 4 pp. Gives a few instances of many successful installations burning pulverized coal that were made under various types of boilers and using many fuels. Abstract of paper in Min. & Metallurgy, no. 180, Dec. 1921, pp. 35–36.

Metallurgical Furnaces. Powdered Fuel. J. S. Atkinson. Iron & Coal Trades Rev., vol. 103, no. 2805, Dec. 2, 1921, p. 802. Recent developments in connection with firing of metallurgical furnaces. Relative costs of gas firing and powdered fuel firing, cost of powdering, etc. (Abstract.) From Fuel Economy Rev.

Preparation and Combustion. The Preparation, Transportation, and Combustion of Powdered Coal. John Blizard. Canada Dept. of Mines, no. 564, 1921, 131 pp., 42 figs. Discusses distribution; feeder, mixers and burners; advantages and disadvantages; use for steam raising, costs of preparing and delivering to furnace; operating and repair costs; etc.

Small-Plant System. Pulverized-Coal System for Small Plants. Power, vol. 54, no. 26, Dec. 27, 1921, pp. 1016–1017, 2 figs. System consisting of self-contained crusher and blower allows pulverized coal to be used in small plants.

Turbo Pulverizer. The Turbo Pulveriser. Iron & Coal Trades Rev., vol. 103, no. 2807, Dec. 16, 1921, p. 877, 1 fig. Describes apparatus built by The Powdered Fuel Plant Co., Ltd., Lond., which is a pulverizing mill and fan combined.

PUMPING PLANTS

Hydroelectric Reservoirs. Pumping Plants for Water-Power Reservoirs (Les installations d'accumulation hydraulique par pompage), Jacques Godin. Révue Générale de l'Électricité, vol. 10, no. 24, Dec. 17, 1921, pp. 881–887, 7 figs. Discusses pumping plants for supplying additional water power to hydroelectric plants which desire to increase beyond their capacity, and gives successful examples in France and Italy.

PUMPS

Mammoth. Mammoth Pumps. Eng. Progress, vol. 2, no. 12, Dec. 1921, pp. 277–278, 3 figs. Describes construction and operation of the pump and its application to raising water, chemical liquids, and solid substances that can be moved in currents of fluids.

PUMPS, CENTRIFUGAL

High-Pressure. The Operation of High-Pressure Centrifugal Pumps (Die Betriebsweise der Hochdruck-Zentrifugalpumpen). Wärme- u. Kälte-Technik, vol. 23, no. 22, Nov. 15, 1921, pp. 253–257, 8 figs. Includes table giving results of tests with a 3-stage high-pressure centrifugal pump for raising 2000 liters of water per minute to height of 112 m., directly coupled with a 75-hp. asynchronous motor with 1480 r.p.m. at 50 periods. Points out advantages and useful field of centrifugal pumps.

Parallel Operation. Operating Pumps or Fans in Parallel. J. C. Hobbs. Power, vol. 55, no. 2, Jan. 10, 1922, pp. 58–60, 6 figs. Discusses problems encountered in parallel operation of centrifugal pumps and explains why pumps must have correct characteristics.

PYROMETERS

Radiation. A New Radiation Pyrometer for the Measurement of High Temperatures (Ein neues Strahlungspyrometer zur Messung hoher Temperaturen), Georg Keinath. Elektrotechnische Zeit., vol. 42, no. 48, Dec. 1, 1921, pp. 1384–1387, 10 figs. With temperatures exceeding 1200 deg. cent. the wear of thermocouple armors is said to be considerable, so that it appears advisable to carry out measurements with radiation pyrometers. A new construction type and its properties are described.

PYROMETRY

Liquid-Fuel-Fired Boilers. Pyrometry of Boilers Fired with Liquid Fuel, E. C. Reed. Eng. & Indus. Management, vol. 6, no. 26, Dec. 29, 1921, pp. 743–746, 4 figs. Describes the Foster fixed focus pyrometer and its application. Writer claims that expense of installation of pyrometer system may be saved many times over in year.

R

RAILS

Reclaiming Worn-Out. Worn-Out Rails—Their Resurrection from Uselessness to Usefulness. Raw Material, vol. 4, no. 11, Nov. 1921, pp. 392–395, 11 figs. Describes operations at Sweet's Steel Co.'s rail reclamation plant, Williamsport, Pa.

Sink-head Ingot Rolling. Sound Steel in Rail Manufacture, Cecil J. Allen. Ry. Engr., vol. 42, no. 503, Dec. 1921, pp. 468–470, 3 figs. Comparison of results obtained by Pennsylvania Railroad with rails rolled from sink-head and ordinary ingots, respectively.

Sorbitic Steel. Wear of Railroad and Street Car Rails (L'Usure des rails de chemins de fer et de tramways), J. Gouttier. Révue Universelle des Mines, vol. 11, no. 5, Dec. 1. 1921, pp. 524–543, 12 figs. Describes Sandberg process of producing sorbitic steel and its successful application to rails.

The Latest in Steel Rails, Frederic C. Carl. Sci. Am., vol. 126, no. 1, Jan. 1922, p. 44. Notes on sorbitic steel rail manufactured according to Sandberg process, which is said to double life of rail while increasing cost only by 20 per cent.

Wear. Causes of Premature Wear of Rails (Les causes de l'usure prématurée des rails). Le Génie Civil, vol. 79, no. 21, Nov. 19, 1921, pp. 429–433, 26 figs. Discusses cracks, fissures, segregation, etc., in rails; effect of tempering, and of natural wear.

RAILWAY CONSTRUCTION

Canada. Development of Canadian Railway Construction, H. K. Wicksteed. Can. Engr., vol. 42, no. 1, Jan. 3, 1922, pp. 104–108. Describes early trade routes and economic conditions which resulted in construction of railways in Canada. Problems solved by engineers when locating trans-continental road. Paper before Am. Assn. for Advancement of Sci.

Grade Reduction. Justifying Expenditures for Grade Reductions, George J. Ray. Ry. Age, vol. 71, no. 26, Dec. 24, 1921, pp. 1243–1250, 5 figs. Shows that the construction of the Clarks Summit-Hallstead line is fully warranted by operating results. (Abstract.) Paper read before Western Soc. Engrs.

RAILWAY ELECTRIFICATION

Advantages. Railway Electrification, Vincent L. Raven. North-East Coast Instn. Engrs. & Shipbuilders, advance paper, no. 3195-P for meeting, Dec. 16, 1921, 24 pp., 9 figs., partly on supp. plate. Deals with advantages which may result from substitution of electric for steam locomotive operation. See also Engineer, vol. 132, nos. 3443 and 3444, Dec. 23 and 30, 1921, pp. 673–674 and 711, 713, 5 figs., partly on supp. plate.

Steel Plant. Electrification of Steel Plant Railroad, R. B. Gerhardt. Iron Age, vol. 108, no. 26, Dec. 29, 1921, pp. 1663–1666. Difficulties are said to include protection of third rail from hot metal spills. Saving in cost 50 per cent. Investment offset by low operating cost. Paper presented before Assn. Iron & Steel Elec. Engrs.

Superpower Plan. Electric Traction Proposed for 11 Railroads. Ry. Elec. Engr., vol. 12, no. 11, Nov., 1921, pp. 409–414, 9 figs. Discusses Superpower Survey report transmitted to the president containing plan providing for the interconnection of a large number of existing plants. By consolidating power supply, electric operation could be made to show saving of 14 per cent.

RAILWAY OPERATION

North Eastern Railway. Surveys, Diagrams and Other Records Prepared by the Engineer's Department of the North Eastern Railway, Conrad Gribble. Ry. Gaz., vol. 35, no. 23, Dec. 2, 1921, pp. 841–848, 7 figs., partly on supp. plate. Line and siding diagrams as substitutes for surveys. Coördination of field work in measuring distances for statistical, operating and commercial purposes. Systematic recording of strength of bridges. Percentage system for recording equivalent weights of locomotives.

Train Dispatching. Management of Single Track Lines in Great Britain (Note sur l'exploitation des lignes a voie unique dans le Royaume-Uni). Review Générale des Chemins de Fer et des Tramways, vol. 40, no. 11, Nov. 1921, pp. 304–318, 14 figs. Discusses ticket, tablet, and token systems of train dispatching, and the various apparatus for exchanging used in connection with them.

RAILWAY SHOPS

Montreal, Can. A Railroad Shop Organized for Efficiency. Machy. (N. Y.), vol. 28, nos. 4 and 5, Dec. 1921, and Jan. 1922, pp. 291–293 and 389–392, 8 figs. Description of Angus shops of Can. Pac. Ry. Co., Montreal, Canada, and equipment and methods employed.

RAILWAY SIGNALING

Interlocking. New Interlockings at Jacksonville Terminal, C. J. Kelloway, Ry. Signal Engr., vol. 14, no. 12, Dec. 1921, pp. 462–468, 18 figs. Developments in the construction of a large electro-pneumatic and two electro-mechanical plants with inter-connecting circuits.

RAILWAY SWITCHES

Electric. Electrically Operated Equipment for Car Handling, R. M. Kintzing. Elec. Rev. (Chicago), vol. 79, no. 21, Nov. 19, 1921, pp. 773–775, 6 figs. Interlocking and limit control switches employed to assure proper sequence in cycle of movements; great saving in labor and increase in plant capacity secured by electrical operation.

RAILWAYS

China. The Peking-Suiyuan Railway of China. Sci. Am., vol. 126, no. 2, Feb. 1922, pp. 116–117, 8 figs. Description of road surveyed, constructed and operated entirely by Chinese.

Development 1921. General Railroad Developments During the Year. Ry. Age, vol. 72, no. 1, Jan. 7, 1922, pp. 9–154, 89 figs. Articles on regulation of securities, labor situation, federal valuation, railroad accounts with the government, profit of railroads from lower material costs, recent tendencies in locomotive development, special types of cars introduced in 1921, maintenance-of-way, cutting freight loss and damage claims, accounting, equipment conditions, electrical developments, repair-shop and enginehouse development, chronological review of year's activities. Also contains articles on railway statistics, including locomotive, freight-car and passenger-car market.

Monorail Suspended Line. Monorail Suspended Railroad Tracks and Canal-Boat Haulage (Système de voies suspendues monorails et systeme de halage des bateaux), M. Mahl. Bul. de la Société Française des Électriciens, vol. 1, no. 7, July 1921, pp. 337–368, 13 figs. Discusses a projected monorail line from Paris to Nice according to the Barmen-Elberfeld system, but with maximum speed of 300 km. per hr., also power transmission and boat haulage as side issues.

REFRACTORIES

Resistance. Resistance Tests on Refractory Products under Load at Different Temperatures, V. Bodin. Quarry & Surveyors' & Contractors' Jl., vol. 26, no. 297, Nov. 1921, pp. 438–440, 3 figs. Results of tests, and table of crushing loads in kg.-cm. (Abstract.) Paper read before Ceramic Soc.

REFRIGERATING MACHINES

Carbon-Dioxide. Carbon-Dioxide Refrigerating Machine, H. J. Macintire. Power, vol. 55, no. 1, Jan. 3, 1922, pp. 24–26, 3 figs. Relative advantages of carbon dioxide vs. ammonia as refrigerating medium, in which pressure range, cooling-water limitations, horsepower per ton, relative size and construction are considered.

Tests on a Carbonic-Acid Refrigerating Machine with Additional Compression under High Condenser Pressures (Versuche an einer Kohlensäurekältemaschine mit Zusatzkompression bei hohen Kondensatordrücken), R. Plank. Zeit. fur die gesamte Kälte-Industrie, vol. 28, no. 11, Nov. 1921, pp. 157–162, 3 figs. Writer refers to process described by him in previous issue of this journal (p. 189, 1913), by use of which, it was claimed, considerable increase of refrigeration output and economy in cold carriers with low critical temperature (CO_2, N_2O), could be effected under poor cooling-water conditions and correspondingly high condenser pressure. Present article gives brief description of process and results of practical test recently carried out demonstrating its practicability.

REFRIGERATING PLANTS

Temperatures and Pressures. Working Temperatures and Pressures in the Refrigeration Plant, W. H. Motz. Power, vol. 54, no. 26, Dec. 27, 1921, pp. 1005–1007, 3 figs. Notes on suction pressures and temperatures; discharge temperatures and pressures; uses of thermometers.

RESEARCH

Fan Industry. Relation of Research to the Fan Industry. Am. Soc. Heat. & Vent. Engrs. Jl., vol. 27, no. 9, Dec. 1921, pp. 873–881. Research in the Heating and Ventilating Field, by J. I. Lyle; and Research as a Business Proposition, by F. R. Still.

ROLLING MILLS

Adjustable-Speed Motors. Adjustable Speed With Motor Driven Mills, K. A. Pauly. Iron Age, vol. 108, no. 25, Dec. 22, 1921, pp. 1595–1598 and (discussion) pp. 1598–1600, 11 figs. Describes two satisfactory systems, with comments on their relative characteristics and particular work for which each is most adaptable. (Abstract.) Paper read before Engrs., Soc. West. Pa.

Continuous. Continuous Rolling-Mills, John W. Sheperdson. Engrs. Soc. of Western Pa. Proc., vol. 37, no. 4, May 1921, pp. 221–252 and (discussion) 253–257, 15 figs. Discusses advantages of continuous rolling process, and describes the various types of continuous mills, viz., billet mills, sheet-bar mills, wire-rod mills, mills for rolling flat finished products, merchant mills, etc.

Friction. Friction in Rolling Mills, William F. Parish. Iron Age, vol. 108, no. 26, Dec 29, 1921, p. 1661. Effects of proper lubrication shown in reduced power losses. (Abstract.) Paper read before Am. Soc. Lubrication Engrs.

Mannesmann Inclined Rolls. Formation of Holes with the Inclined Roll (Mannesmann) Process (Ueber die Lochbildung beim Schrägwalzverfahren), J. Gassen. Stahl u. Eisen, vol. 41, no. 49, Dec. 8, 1921, pp. 1767–1771, 13 figs. Writer's experiences with formation of cracks with hollow ingot rolling. It is shown that most favorable but also most difficult position for axis of rolling material is exactly in center of both rolls at point of crossing.

Production and Yield. Production and Yield of Rolling Mills, Joseph F. Shadgen. Iron Age, vol. 109, nos. 1 and 2, Jan. 5 and 12, 1922, pp. 43–46 and 151–152, 1 fig. Jan. 5: Their present state of development. Useful operating data. Losses which should be lessened. European practice leads in yield. Jan. 12: Dependence of material yield on oxidation and on bloom and billet cropping. Temperature limitations are said to govern reheating.

Semi-Continuous Bar. Semi-Continuous Bar Mill for Alloy Steel, F. L. Prentiss. Iron Age, vol. 109, no. 2, Jan. 12, 1922, pp. 142–144, 5 figs. Cooling equipment embodies inclined escapement and horizontal notched bed features. Flat spring steel is self-annealed in packs.

Tandem Rolling. Tandem Rolling of Cold-Rolled Steel. Iron Age, vol. 109, no. 3, Jan. 19, 1922, pp. 211–213, 7 figs. Special equipment developed for this purpose, including rolls and their housings, wire straighteners, edge rolls, Turk's head and cross slides.

RUBBER

Stress-Elongation Curve. The Stress-Elongation Curve of Vulcanized India-Rubber, Emil Hatschek. Jl. Soc. Chem. Industry, vol. 40, no. 21, Nov. 15, 1921, pp. 251T–253T, 3 figs. Compares curves for samples of a definite rubber-sulphur mixture cured for definite lengths of time, and deduces formulas.

Testing. The Testing of Rubber Goods. U. S. Bur. of Standards Circular, no. 38, Sept. 28, 1921, 127 pp., 47 figs. Gives methods used at Bureau in testing of rubber goods. Describes various physical tests commonly applied and machines used for this purpose, many of which were designed in Bureau.

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S

SCIENTIFIC MANAGEMENT

See INDUSTRIAL MANAGEMENT.

SCREWS

Efficiency. Efficiency of Screws, C. D. Albert. Sibley Jl. of Eng., vol. 36, no. 1, Jan. 1922, pp. 2–3, 1 fig. Comparison of correct and approximate expressions.

SEMI-DIESEL ENGINES

Hydroelectric Plant. A Combined Hydro and Semi-Diesel Plant at Minnedosa, Manitoba. Power, vol. 55, no. 3, Jan. 17, 1922, pp. 92–93, 2 figs. Semi-Diesel engines installed in hydroelectric plant to carry load during periods of low water.

SEWAGE DISPOSAL

The Economy of the OMS Sewage Purification Process. (Wirtschaftlichkeit und Frischwasserklärung bei dem OMS-Verfahren in Gegensatz zu nebengelagerten Schlammfaulräumen), H. Schnickel and O. Mohr. Gesundheits-Ingenieur, vol. 44, no. 43, Oct. 22, 1921, pp. 545–547. Schinckel disputes the practicability of the OMS process, because the fresh-water settling tank is in constant connection with the putrefying chamber. In his reply, Mohr points out that neither is purely fresh sludge recovered from the Kremer purification process, according to which the putrefying chamber is located parallel to settling tank.

SHAFTS

Oscillations. Calculation of Torsional Oscillations of Shafts (Zur Berechnung der Verdrehungsschwingungen von Wellenleitungen), J. Geiger. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 48, Nov. 26, 1921, pp. 1241–1242, 6 figs. Describes new and very simple method of determining coefficient of torsional oscillation and the true angle of deviation; and method of calculating reduced length of crank.

SHEET-METAL WORK

Elbows. New Machine Making Two Elbows a Minute. Sheet Metal Worker, vol. 12, no. 25, Jan. 6, 1922, pp. 854 and 855, 2 figs. Describes Lyon-Conklin elbow machine which turns blank sheets into elbows.

SHIPS, CONCRETE

Resistance. The Resistance of Reinforced-Concrete Ships (Das Eisenbetonschiff und sein Widerstand), L. Kostanjevic. Beton u. Eisen, vol. 20, no. 17–18, Nov. 4, 1921, pp. 199–200. Writer presents a few practical examples supplementary to article by F. Gebers in previous issue of same journal.

SILICA BRICK

Manufacture. The Manufacture of Silica Brick, A. W. McMaster. Iron & Steel of Can., vol. 4, no. 10, Nov. 1921, pp. 267–268. Describes inauguration of the manufacture at Cape Breton from local materials. Operating costs; comparative analyses of quartzites; burning.

SLIDE RULES

Decimal Point Determination. Decimal Point Determination in Slide Rule Operation, James Theron Rood. Wisconsin Engr., vol. 26, no. 2, Nov. 1921, pp. 19–22, 3 figs. Gives examples to show how to secure greater accuracy.

SLOTTING MACHINES

Horizontal. Investigation of a Horizontal Slotting Machine with Electric Separate Drive and Belt Coupling Devices (Untersuchung einer Wagerechtstoszmaschine mit elektrischem Einzelantrieb und Riemenzwischengliedern), G. Schlesinger. Werkstattstechnik, vol. 15, no. 22, Nov. 15, 1921, pp. 645–647, 7 figs. Abstract of comprehensive work giving results of many years of research and experimental work carried out by author in coöperation with Dr. Kurrein. Results are shown in diagrams on performance of machine and on manner of power distribution during forward and return stroke.

SMOKE PREVENTION

Devices. The Black Smoke Problem, David Brownlie. Iron & Coal Trades Rev., vol. 103, no. 2807, Dec. 16, 1921, pp. 872–873. Causes and preventive devices; low-temperature carbonization.

SPRINGS

Railway-Car. The Springs of Railway Cars (Om Jærnbanevognes Fjedre), Rich. Holm. Ingeniören, vol. 30, no. 67, Aug. 20, 1921, pp. 497–501, 14 figs. Form of plate ends is claimed to be of great influence. Shape of ends should be parabolic and the trapeze shape is inexpedient. A spring with parabolic ends can absorb double the work of one with ends cut off at right angles.

STANDARDIZATION

Place of Laboratory in. The Place of the Laboratory in Standardization, W. P. Dobson. Eng. Inst. Can. Jl., vol. 5, no. 1, Jan. 1922, pp. 11–15, 6 figs. Types of engineering standards; measurement, constants, quality, performance; practice; work of laboratory in determining standards, methods employed by laboratories of Hydroelectric Power Commission of Ontario.

STANDARDS

German N.D.I. Report. Report of the German Industry Committee on Standards (Mitteilungen des Normenausschusses der Deutschen Industrie). Betrieb, vol. 3, no. 25, Sept. 15, 1921, pp. 367–379, 18 figs. Accepted standards for blank cylinder, round-head, and countersunk-head screws. Proposals of Board of Directors for drawings for recording dimensions; straight wooden stairs for small dwellings; window and door hinges. Proposed standards for screw joints.

Report of the German Industry Committee on Standards (Mitteilungen des Normenausschusses der Deutschen Industrie). Betrieb, vol. 3, no. 26, Sept. 25, 1921, pp. 393–406, 21 figs. and supp. table. Proposals of Board of Directors for ball bearings. Proposed new standards for round-head rivets for boiler and structural steel work; countersunk-head rivets and countersunk oval heads.

STEAM

Generation and Utilization. Fuel Economy by the Adoption of Scientific Management in Steam Generation and Utilisation, David Brownlie. Eng. & Indus. Management, vol. 6, nos. 23, 24 and 25, Dec. 8, 15 and 22, 1921, pp. 653–656, 7 figs.; 685–687, 4 figs.; and 719–722, 5 figs. Dec. 8: Feedwater heaters. Dec. 15 and 22: Superheaters, and boiler and pipe covering.

STEAM-ELECTRIC PLANTS

Equipment. Rauber's Report to the Commission for Utilization of Fuels (Rapport de M. Räuber a la Commission d'utilisation des combustibles). Chaleur et Industrie, vol. 2, no. 19, Nov. 1921, pp. 727–735. Discusses steam-electric central stations, their equipment, type of boilers, superheat, economizers, feedwater heaters, etc.

STEAM ENGINES

Unaflow. Unaflow-Engine Guarantees and Tests, L. A. Quayle. Power, vol. 55, no. 3, Jan. 17, 1922, pp. 98–99, 1 fig. Universal unaflow engine exceeds guarantees on acceptance tests made after four years of continuous operation.

STEAM METERS

Kent Marine. The Metering of Steam for Marine Purposes, also of Oil and Air, C. R. Sams. Trans. Inst. Mar. Engrs., vol. 33, Oct. 1921, pp. 375–388 and (discussion) 388–393, 10 figs. Describes the Kent steam meter which consists of an orifice carrier, cooling chambers and pressure piping, and a diagram recorder.

STEAM TURBINES

Design and Operation. Major Turbine Troubles Diminished. Elec. World, vol. 79, no. 2, Jan. 14, 1922, pp. 77–80, 2 figs. Discusses blading, lubrication, and vibration; growth in turbine ratings; improvements in design.

STEEL

Chrome. See CHROME STEEL.

Crucible. Comparison of American and English Methods of Producing High Grade Crucible Steel, T. Holland Nelson. Raw Material, vol. 4, no. 12, Dec. 1921, pp. 424–433, 24 figs. Discusses the merits and shortcomings of American and English practice. Presented before Am. Soc. for Steel Treating.

Deoxidation and Desulphurization. Deoxidation and Desulphurization in the Heroult Furnace, F. T. Sisco. Chem. & Met. Eng., vol. 26, no. 1, Jan. 4, 1922, pp. 17–22. Describes three methods of working up a heat of steel. Discusses composition and characteristics of slags. Believes that good steel from poor scrap is a question of knowledge and skill.

Electric vs. Crucible. Crucible and Electric Tool Steel, W. J. and S. Stuart Green. Iron Age, vol. 109, no. 3, Jan. 19, 1922, pp. 201–205. Some aspects and choice in their manufacture. Points out that electric furnace bids fair to supplant crucible to greater degree than heretofore, though it is possible never completely.

Etched, Strain Figures in. Strain Figures in Etched Steel, A. Fry. Engineering, vol. 112, no. 2920, Dec. 16, 1921, pp. 809–811, 11 figs. Examples of peculiar strain figures observed by author on specimens of mild steel etched according to a modified new method. Author points to parallel between his observations and what is known as "blue brittleness."

Hardening by Overstrain. The Hardening of Steel by Overstrain, R. W. Chapman. Commonwealth Engr., vol. 9, no. 3, Oct. 1, 1921, pp. 74–75, 2 figs. Describes test showing that when steel is overstrained in tension so that its elastic limit in tension is raised, its elastic limit in compression is correspondingly lowered, and vice versa.

Manganese. See MANGANESE STEEL.

Melting. Leaves from a Steel Melter's Notebook, Henry D. Hibbard. Iron Age, vol. 108, nos. 17 and 21, Oct. 27 and Nov. 24, 1921, pp. 1065–1067 and 1337 and 1379–1380. Oct. 27: Experience in making hollow ingots for seamless pipe; effervescing and "killed" steel in an acid furnace. Nov. 24: Design of structure to resist shock or overstrain; car-coupler test illustrating necessity of proper distribution of metal.

Molybdenum. See MOLYBDENUM STEEL.

Ordnance. Effect of Sulfur and Oxides in Ordnance Steel, William J. Priestley. Trans. Am. Inst. Min. & Metallurgical Engrs., no. 1109-S, 1921, 15 pp., 3 figs. Describes method by which desired physical properties of steel may be procured—by elimination of certain impurities that inherently exist in steel made by open-hearth process, and without use of expensive alloys. Abstract of paper in Min. & Metallurgy, no. 180, Dec. 1921, pp. 34–35. See also Iron Age, vol. 108, no. 26, Dec. 29, 1921, pp 1658–1661, 3 figs.

Tungsten, Metallography. A Metallographic Study of Tungsten Steel (En metallografisk studie av volframstål), Axel Hultgren. Jerkontorets Annaler, vol. 105, no. 12, 1921, pp. 499–525, 22 figs. Discusses investigations as to transformations, critical points, free carbide, equilibrium diagrams and their signifiance, etc. Bibliography.

STEEL CASTINGS

Railway Rolling Stock. Large Steel Castings for Railway Rolling-Stock, Ry. Engr., vol. 42, no. 503, Dec. 1921, p. 445, 3 figs. Describes production in the form of single castings, of locomotive tender underframes, platform and end members for passenger rolling-stock and trailer trucks for locomotives by Commonwealth Steel Co., St. Louis.

STEEL, HEAT TREATMENT OF

Characteristic Curves. Characteristic Curves for Heat Treatment of Steels (Les "Courbes caracteristiques" des traitments thermiques des aciers), Albert Portevin and Pierre Chevenard. Révue de Metallurgie, vol. 18, no. 11, Nov. 1921, pp. 717–726 and (discussion) 727–728, 11 figs. Discusses the interdependence of temperature of heating and rapidity of cooling, the final state being a function of these two variables. Paper read before Iron & Steel Inst., Paris.

Elements. Elements of the Heat-Treatment of Steel, H. J. French. Am. Mach., vol. 55, nos. 23, and 24, Dec. 8 and 15, 1921, pp. 907–908 and 960–964, 15 figs. Dec. 8: Operations in heat treatment; changes in structure while heating; changes produced by tempering and hardening; seasoning; effect of carburization. Dec. 15: Quenching operations; tempering.

Tool Steel. Volume Changes in Tool Steel on Heat Treating, L. A. Lanning. Forging & Heat Treating, vol. 7, no. 12, Dec. 1921, pp. 610–611, 2 figs. Effect of rates of heating, temperatures and quenching medium upon dimensions of cylindrical pieces of tool steels. Critical rate of heating important in hardening.

STEEL, HIGH-SPEED

Hardness. Hardness of High-Speed Steel, A. H. d'Arcambal. Chem. & Met. Eng., vol. 25, no. 26, Dec. 28, 1921, pp. 1168–1173, 8 figs. Hardness at various temperatures, hardness in the cold after various heat treatments, and cutting efficiency determined in an effort to predetermine usefulness of a modern machine tool.

Various Methods for Hardening High-Speed Steel, A. H. d'Arcambal. Chem. & Met. Eng., vol. 25, no. 25, Dec. 21, 1921, pp. 1150–1151. Discusses salt bath hardening, pack hardening, lead bath hardening, and semi-muffle furnace hardening.

Metallography. The Metallography of High Speed Steel, J. P. Gill and L. D. Bowman. Am. Soc. for Steel Treating Trans., vol. 2, no. 3, Dec. 1921, pp. 184–205, 56 figs. Discusses critical points and constitution of high-speed steels; secondary hardness; etching reagents; nomenclature; etc.

STEEL MANUFACTURE

Basset Process. The Basset Process (Le Procédé "Basset"). L'Outillage, vols. 235 and 236, nos. 47 and 48, Nov. 24 and Dec. 1, 1921, pp. 1259–1260 and 1287–1288, 1 fig. Gives copy of Basset's French patent published April 2, 1920, "Rotary furnace system for direct production of iron or steel or of pig iron," and discusses it and its prospects.

STEEL WORKS

Cold-Drawing Plant. LaSalle Co. Completes Cold Drawing Plant, Gilbert L. Lacher. Iron Age, vol. 109, no. 1, Jan. 5, 1922, pp. 27–31, 6 figs. Designed for handling products in maximum lengths. Raw materials protected from elements.

Furnaces and Gas Producers. Steel Works Furnaces and Gas Producers, J. S. Atkinson. Jl. West of Scotland Iron & Steel Inst., vol. 29, Part 1, Oct. Session 1921–1922, pp. 4–14 and (discussion) 11–14, 10 figs. on supp. plates. Discusses the principle of gas firing, mechanical producers, regeneration or recuperation, open-hearth furnaces, soaking pits, etc.

Krupp. Recent Developments in the Krupp Works at Essen. Engineer, vol. 132, no. 3441, Dec. 9, 1921, pp. 611–613, 8 figs. partly on p. 632. Account of its development and details as to its work during war and peace-time activities.

Power Generation. Power Generation in Steel Plants, D. M. Petty. Engrs. Club of Philadelphia Jl., vol. 38–12, no. 204, Dec. 1921, pp. 392–397, 2 figs. Conclusions drawn from actual operating conditions of steel plant: Cost of power can be effectively reduced by increasing load factor; load factor in steel mills may be increased by careful arrangement of load and by supplying to central stations all surplus power not required during light load periods; etc.

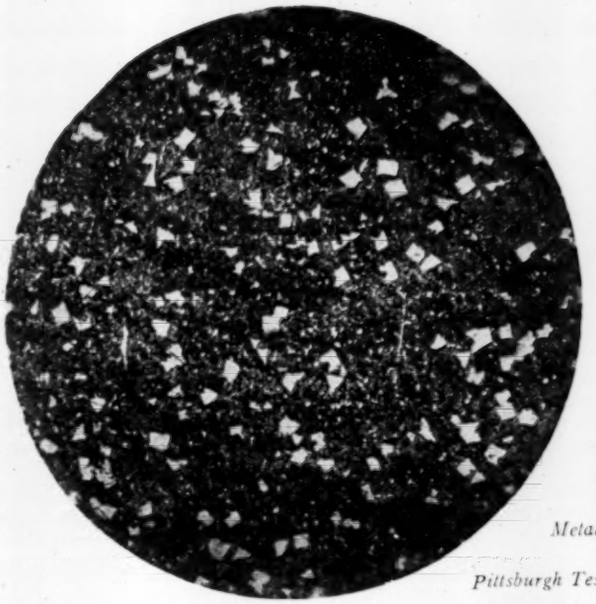
STOKERS

Mechanical vs. Hand. Hand *versus* Mechanical Handling of Coal and Ashes in Municipal Power Plants—II, W. F. Schaphorst. Am. City, vol. 25, no. 5, Nov. 1921, pp. 415–421, 2 figs. Notes on underfeed and hand stokers, and points to be considered in selection of ash-handling system.

Wood-Refuse-Burning. Burning Wood Refuse in Mechanical Stokers, R. L. Beers. Power House, vol. 15, no. 1, Jan. 5, 1922, pp. 30–33, 8 figs. Describes various types of boilers fitted with underfeed stokers for wood and other factory refuse.

SUPERHEATERS

Design. Steam Superheaters, Arthur D. Pratt.



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